Gibbons

Volume 66
Number 1

March, 1952
Pages 1-127

$4.00 a Year
$1.25 a Number

Journal of the New England Water Works Association

ISSUED QUARTERLY

Published by
NEW ENGLAND WATER WORKS ASSOCIATION
73 Tremont Street, Boston 8, Massachusetts

Entered as second-class matter September [illegible], [illegible], in the Post Office at Boston, Mass., under Act of Congress of March 3, [illegible]
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THE Association was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of 900 men. Its membership is divided into six classes, viz.:

A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

A Junior shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

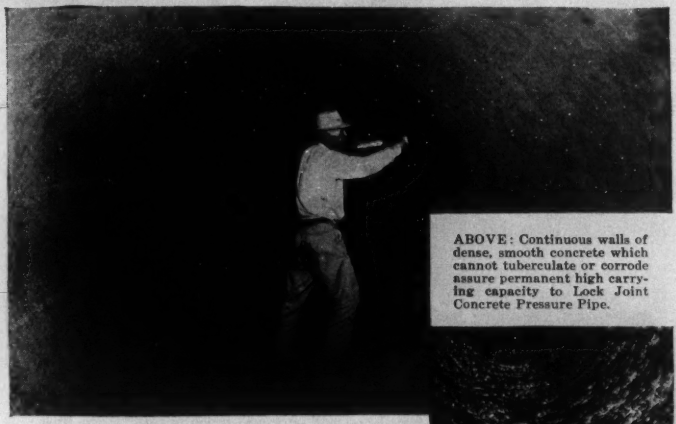
A Corporate Member shall be either a Water Board, Commission, Company or Municipal Corporation.

The initiation fees and annual dues are as follows:

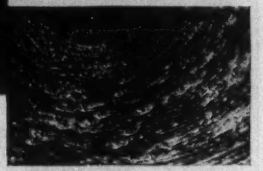
Initiation Fees		Annual Dues	
Members	$ 5.00	Members	$ 5.00
Juniors	1.00	Juniors	5.00
Associates	10.00	Associates	10.00
Corporate Members	10.00	Corporate Members	10.00

This Association has at least eight regular meetings each year, of which five are held in Boston, one in northern New England, one in southern New England, and one, the annual convention, held in September on such date as the Executive Committee may designate.

CONCRETE *is the answer to your main problem*



ABOVE: Continuous walls of dense, smooth concrete which cannot tuberculate or corrode assure permanent high carrying capacity to Lock Joint Concrete Pressure Pipe.



ABOVE: The tuberculated condition of this metallic pipe reduces its carrying capacity 50%.

Tuberculated mains—corroded mains—leaky mains—all cost municipalities, taxpayers and industry immense sums every year in added pumping costs, maintenance and repairs. Yet, by the use of Lock Joint Concrete Pressure Pipe, all of this unnecessary expense could be eliminated.

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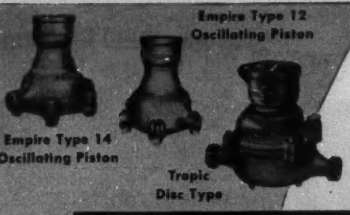
Lock Joint Pipe Company for over forty years has specialized exclusively in the manufacture of reinforced concrete pipe for water supply and transmission mains as well as for sewers, culverts and subaqueous installations.



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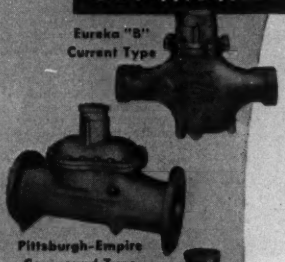

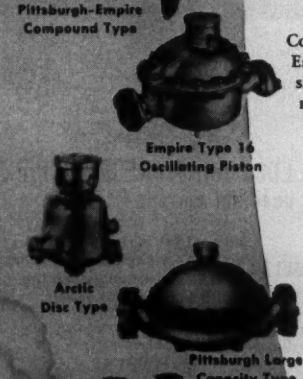

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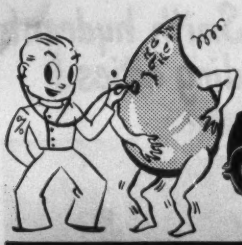

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Many are the reasons why Smith hydrants are used by America's leading cities!

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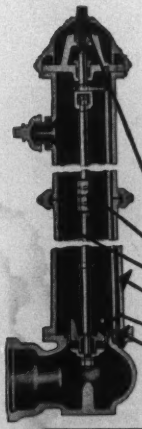

New York — Philadelphia — Washington — Baltimore — St. Louis — Providence and scores of other cities throughout the nation use SMITH hydrants — and not without good reason. A few of these reasons can easily be seen upon inspection of the hydrant section shown at the left.

1. Working parts easily removed from top.
2. Frangible couplings for collision protection.
3. Maximum flow due to large stand pipe areas.
4. Tapered, frost-proof barrel
5. Compression-type valve.
6. Positive action drain—always closed when main valve is open.

31

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ESTABLISHED 1874

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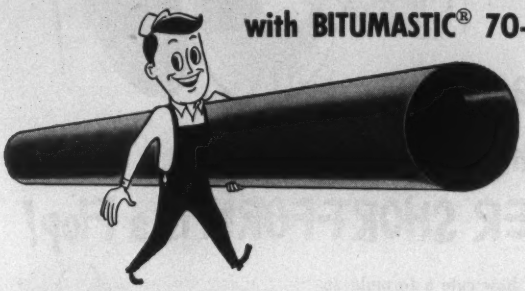
NO NEED TO SPECIFY OVER-SIZED PIPE

. . . when you protect pipe lines with BITUMASTIC® 70-B ENAMEL



PIPE LINES DON'T "SHRINK" when they're protected by Bitumastic 70-B Enamel. This durable enamel coats interior surfaces with a smooth, spun lining—a lining that prevents rust, corrosion and tuberculation.

With this kind of protection, there's no need to waste money on *over-sized* pipe in order to allow for future "shrinkage." You select pipe for your water lines solely on the basis of desired capacity.

Bitumastic 70-B Enamel saves money on pumping costs, too. That's because it *keeps* flow capacity high. It isn't necessary, even after decades of service, to install bigger pumps that cost more to buy and operate.

Bitumastic 70-B Enamel also protects exterior surfaces of pipe lines. It prevents pitting and leakage caused by soil corrosion. Here, again, you save money on maintenance and replacements.

It will pay you to protect your community's steel pipe lines with Bitumastic 70-B Enamel. If you wish, our Contract Department will handle your coating jobs from start to finish, furnishing skilled men and specialized equipment. Write for full information.

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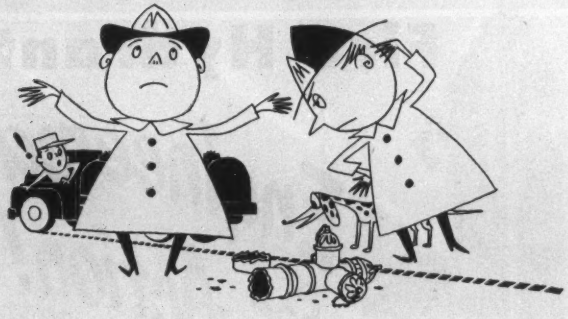
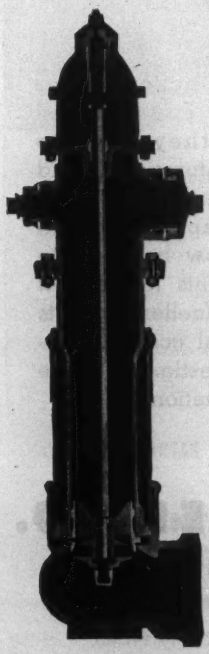
Broken hydrant cannot leak!





The main valve opens against water pressure and closes with it. This is foolproof protection against flooding when hydrants are broken in traffic accidents.

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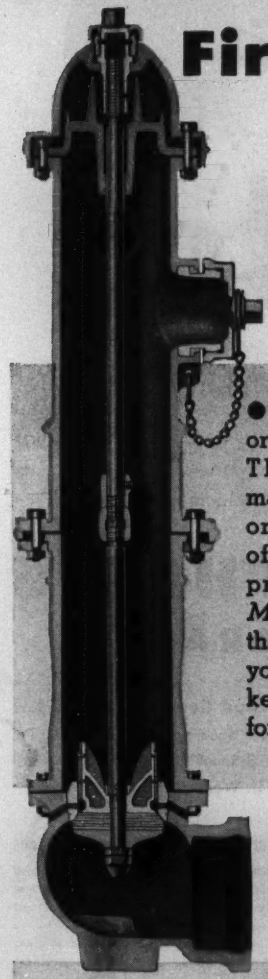

Engineered for Action!

● Engineered for action winter or summer. Mueller Fire Hydrants! That's because they have so many vital extra features not found on ordinary hydrants. 94 years of engineering experience and practical know-how have made *Mueller* fire hydrants *leaders* of the industry. With Mueller hydrants you'll save on initial cost and upkeep expense. Investigate. Write for additional information.

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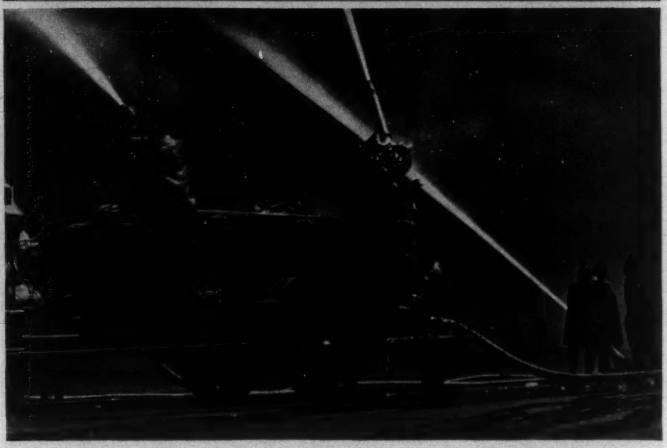
Dependable Since 1857

CHATTANOOGA, TENNESSEE

when water pressure means the most



City officials, municipal and industrial engineers shoulder a tremendous responsibility in the maintenance of water pipe lines. They know that pressure failure due to leakage or tuberculation can often have disastrous results.

Today, the neglect of water lines—however old—is uneconomic. The Centriline process of centrifugally applying cement-mortar lining to pipe lines *in place* virtually makes new pipes out of old at a fraction of the cost. Centrilining, not only prevents tuberculation and leakage, but totally eliminates corrosion to the inner walls. Pumping costs are lower, maintenance reduced and the saving over new pipe lines often amounts to many thousands of dollars.

Write today for your free copy of our new bulletin describing the Centriline process.

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A subsidiary of Raymond Concrete Pile Co.

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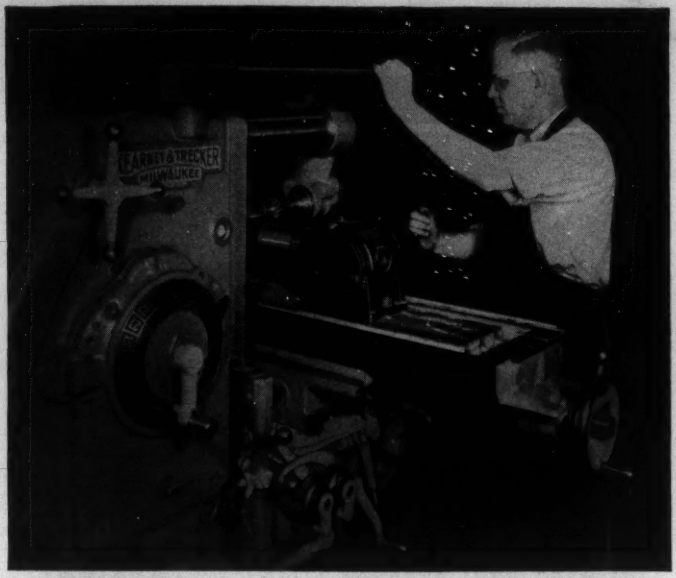

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Transite Pipe is a product of modern engineering and research. Shown above is one of the buildings at the Johns-Manville Research Center at Manville, New Jersey.

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asbestos-cement PRESSURE PIPE

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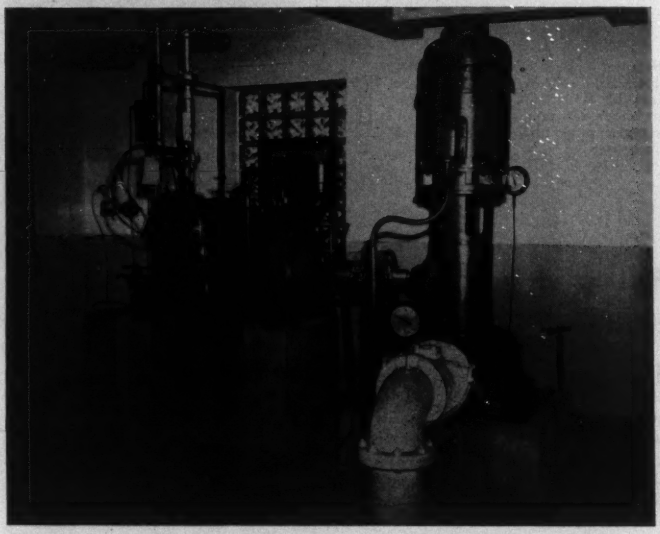

3 Stage Fairbanks, Morse-Pomona

The Fairbanks, Morse Fig. 6977, water lubricated, deep well turbine pump, pictured above has been supplying water to the town of Concord faithfully since its installation in 1949.

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Paul R. Shafer

FREDERICK O. A. ALMQUIST

President of the New England Water Works Association, 1951-52.

New England Water Works Association
ORGANIZED 1882

VOL. LXVI MARCH, 1952 NO. 1

This Association, as a body, is not responsible for the statements or opinions of any of its members

RESIDUAL CHLORINE BY AMPEROMETRIC TITRATION

BY HENRY C. MARKS*

[*Read at Chemists' Round Table, December 21, 1950.*]

The amperometric titration method is now generally understood to include all procedures wherein the end-point in a titration is indicated by some modification of a polarographic reading. The general procedure has been in use for about 25 years and in the last 10 years has been applied to many different analytical problems (1).

The polarographic method involves continuously measuring a varying electric current, caused by a changing voltage impressed on a cell, one electrode of which is polarized to some extent. In any cell consisting of two electrodes contacting an electrolyte, the impressed voltage will be opposed by counter-voltage. This results from the accumulation of the electrolysis products or the exhaustion of material being electrolyzed at the electrode surfaces. The current that can flow is said to be decreased by concentration polarization.

At the negative electrode (cathode) flow of current will cause accumulation of reducing agents, while at the positive electrode (anode) oxidizing agents will accumulate. Addition of an oxidizing agent to the cathode solution or a reducing agent to the anode solution will decrease this accumulation, depolarizing the electrode and reducing the counter-voltage to allow more current to flow.

This dependency of current on concentration of oxidizing or reducing agent at the respective electrodes makes such a cell useful as an end-point indicator. To titrate an oxidizing agent only the negative electrode should be affected. In this case the positive electrode is made non-polarizable. As the oxidizing agent is titrated with a suitable reagent and its concentration decreased, the current through the cell decreases correspondingly. When all the oxidizing agent has

*Director of Chemical Research, Wallace & Tiernan Co., Inc., Newark, N. J.

been titrated, the end-point is indicated by no change in current on further addition of reagent.

The exact method in general analytical use could not be directly applied to the determination of residual chlorine, because of the unusually low concentrations and the unusually low conductivity of the sample. Marks and Glass (2) in 1942 described a cell design that overcame these obstacles by (a) large electrode surface, (b) short electrical path through the water sample and (c) efficient agitation. This design has been steadily improved (3) and the instrument presently in use is shown in Figure 1.

The indicating electrode is made to have large surface area by forming it in the shape of a ribbon, wound spirally around a lucite cylinder. The electrical path through the water is made short by providing a salt-bridge contact through holes in the lucite cylinder, drilled at intervals in the narrow space between the turns of the platinum spiral. Diffusion of the saturated salt solution from within is prevented by wrapping thread around the cylinder, so as to cover these holes but still provide electrical contact. Efficient agitation is obtained by high-speed rotation of a lucite sleeve, which fits over the cylinder with minimum clearance. The non-polarizable anode is a silver tube, immersed in saturated salt solution inside the lucite cell. The potential of this silver electrode is such that it provides an internal voltage and makes it unnecessary to impress an external voltage. The electric current flowing from this cell is put directly through a microammeter. The calibration of this meter is unimportant and the position of the needle can be adjusted to any convenient position on the scale. For this is provided a small opposing voltage, tapped from a suitable electric winding in the electric motor circuit and rectified.

With the above cell immersed in the water sample, electric-current decrease as titrating reagent is added is indicated by movement of the microammeter needle. By using the opposing voltage to keep the needle suitably located on the scale, changes in current are easy to observe. At the end-point further addition of the reagent will cause no change in the position of the needle.

An electrometric end-point indicator has numerous advantages over a colorimetric: (a) it avoids the difficulties of visual color matching; (b) its usefulness is not impaired by turbidity or color in

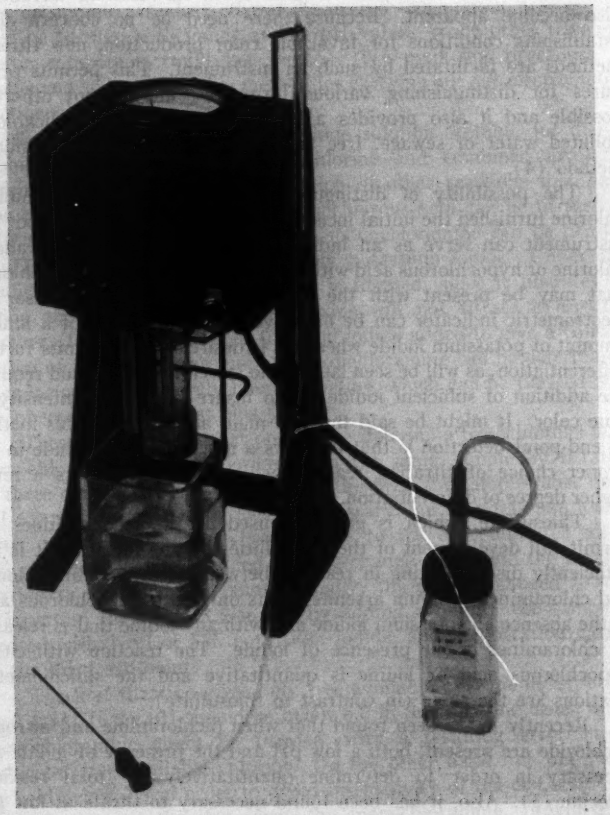

FIG. 1.—AMPEROMETRIC TITRATOR.

the sample; (c) it is easier to avoid interferences by substances such as manganese and nitrites. Certain more far-reaching advantages also become apparent. Because there need be no concern about establishing conditions for favorable color production, new titration methods are facilitated by such an instrument. This permits procedures for distinguishing various forms of chlorine not otherwise possible and it also provides a basis for procedures applicable to polluted water or sewage, free from the faults of the orthotolidine method (4).

The possibility of distinguishing between free and combined chlorine furnished the initial incentive for developing this method. The instrument can serve as an indicator for titration of free available chlorine or hypochlorous acid without disturbing other residual chlorine that may be present with the proper titrating reagent. Also, the electrometric indicator can be used even in the presence of a limited amount of potassium iodide when this is desired. This permits further differentiation, as will be seen later. The starch-iodide method requires the addition of sufficient iodide ion to insure the proper intensity of blue color. It might be said that the main advantage of this method of end-point detection is that it allows a much greater latitude in the proper choice of titrating reagent, which in turn permits a much higher degree of differentiation.

Thiosulfate, which is generally used as the reagent, does not permit full development of the possibilities of this method. It is not sufficiently discriminating in reaction between free available chlorine and chloramines. Sodium arsenite reacts only with hypochlorous acid in the absence of potassium iodide and with any iodine that is released by chloramines in the presence of iodide. The reaction with either hypochlorous acid or iodine is quantitative and the stoichiometric relations are the same (in contrast to thiosulfate).

Recently it has been found that when dichloramine and nitrogen trichloride are present, both a low pH and the presence of iodide are necessary in order to determine quantitatively the total residual chlorine (5). Also, it has been found necessary to titrate at low pH in determining residual chlorine in sewage. Since arsenite does not react rapidly and quantitatively either with free chlorine or with iodine at pH values below 6, it was necessary to find a more suitable reagent.

The usefulness of phenylarseneoxide solution in this capacity was hinted at by some work in the pharmaceutical field. In connection with work on organic arsenicals, it was discovered that organic arseneoxide could be titrated with iodine at low pH values, while other trivalent arsenic compounds could not be (6). We used this procedure in reverse and so had a suitable method for carrying out our electrometric titration at low pH.

Not only is the phenylarseneoxide solution suitable for distinguishing between free available chlorine and combined available chlorine, but it also permits utilization of other reactions that have been recently discovered. While hypochlorous acid can be titrated at pH 7 with the addition of no iodide, monochloramine can be titrated at pH 7 with the addition of 50 ppm potassium iodide. Under this condition none of the dichloramine is titrated, since it liberates no iodine and since the phenylarseneoxide will not titrate it directly. Further, if the pH is lowered to 4 and iodide added to give a concentration of 250 ppm potassium iodide, dichloramine can be determined, since it now quantitatively liberates iodine, which can be titrated with the phenylarseneoxide at this pH.

These reactions make it possible to determine hypochlorous acid, monochloramine and dichloramine on the same sample by titrating to three consecutive end-points. For the first, the sample must be at pH 6.0 to 7.5, buffer being used if necessary, but no potassium iodide. After titrating with phenylarseneoxide to the end-point, 0.2 ml of 5% potassium iodide is added with no change in pH and the titration carried to a second end-point. Finally, the pH is changed so that it is within the range 3.5 to 4.5 by adding a buffer; the sample is treated with 1 ml of 5% potassium iodide, and the titration carried to the third end-point.

The first titration gives only free available chlorine or hypochlorous acid. If the pH should go below 6.0 in this titration, some of the monochloramine might be titrated, with a resulting error in the value for free available chlorine. On the other hand, the pH should be held below 7.5 in order to avoid insensitivity of the cell.

The second titration gives the monochloramine, provided the proper conditions are maintained. If the pH goes below 6.0 or the potassium iodide concentration above 50 ppm, some of the dichloramine

will be erroneously included in this fraction. The third titration will include the dichloramine which is left in the sample. If the pH goes above 4.5 or the potassium iodide concentration falls much below 250 ppm, some of the dichloramine may not react to liberate iodine and the result will be low. On the other hand, the pH should not be permitted to go below 3.5, since manganese or nitrites would then titrate and introduce an error.

The interpretation of the various increments of the titration is strictly valid only in the absence of nitrogen trichloride. It has been realized for a long time that nitrogen trichloride can be present when high chlorine doses are used, even though the pH is 7 or higher (2). The actual concentrations of nitrogen trichloride likely to be encountered are not accurately known, but it is quite certain that they are of a low order of magnitude. Any nitrogen trichloride that is titrated in this procedure will appear partly in the first fraction as free available chlorine and partly in the third fraction as dichloramine. It will be recalled (7) that the starch-iodide titration includes only 80% of the nitrogen trichloride present, while the orthotolidine method includes only 60%. The amperometric titration method has been found to check the starch-iodide with respect to nitrogen trichloride determination. This means that while the presence of nitrogen trichloride might produce a small error in the estimated concentration of free available chlorine and dichloramine, it will not prevent the method from giving a very close agreement with the starch-iodide method for total chlorine residual.

Palin (8) has proposed an extraction method for determining nitrogen trichloride. The sample is extracted with carbon tetrachloride, which removes nitrogen trichloride but not hypochlorous acid. Titration without potassium iodide after extraction gives an estimate of the true hypochlorous acid content. Such an extraction procedure is quite cumbersome, since great care is required to avoid losses of chlorine on the one hand and to extract the nitrogen trichloride quantitatively on the other. Because the nitrogen trichloride concentrations are usually low, it is not considered necessary to apply this extraction method as a means of correcting the amperometric titration when determining merely free chlorine, monochloramine and dichloramine. In those cases where there is a specific interest in nitrogen trichloride itself, this or some alternative method would have to be used.

The presence of organic amines can also interfere with the interpretation of the differential titration. These substances frequently form mono-chloramines and dichloramines as readily as ammonia itself. Since the presence of the organic radical changes the properties of the compounds, it is not to be expected that monochloro organic amines will be found in the monochloro fraction and dichloro organic amines in the dichloro fraction. It is possible that part of any organic chloramine present will be found in each of the two fractions. It is more likely that it will all appear in the dichloramine fraction. Furthermore, it is known that some organic chloramines are so inert that they will not quantitatively liberate iodine, even under the conditions found adequate for dichloramine. This means that there may be small residues of highly inert organic chloramines, not included in the titration as outlined above. Fortunately, these organic amines are present either not at all or in very small quantities, unless the water is highly polluted. When the pollution is sufficiently great, the problem becomes similar to that of sewage, where free available chlorine and even ordinary dichloramine is unlikely to exist. Hence, the differential titration would not be of interest anyway. Consequently, it is only important in the intermediate case of a water which is very high in organic nitrogen.

It is becoming increasingly important to have a good method for determining chlorine dioxide in the presence of various forms of residual chlorine, because chlorine and chlorine dioxide are so frequently found together. Indeed, the most common way of generating chlorine dioxide is by a reaction involving excess chlorine. Haller and Listek (9) have published a method for determining chlorine, chloramines, chlorine dioxide and chlorite by amperometric titration, using four different samples. Only two of the titrations are needed to determine chlorine dioxide itself. Both samples are titrated amperometrically at neutral pH with arsenite, a large excess of potassium iodide being used. In one of the samples, however, the chlorine dioxide is first destroyed, by raising the pH up to 12 and maintaining it there for a definite time period. Since the one titration supposedly includes chlorine, chloramines and chlorine dioxide, while the other includes only the chlorine and chloramines, the difference between the two measures the chlorine dioxide concentration.

While this is the only method now available, it leaves much to

be desired. To begin with, the complete destruction of the chlorine dioxide in the one sample is very critically dependent on pH. Practically, it is a difficult matter to make certain that the pH is held at the necessary high value for the proper length of time. On the other hand, if rigid control over this factor is not exercised, not all of the chlorine dioxide will be destroyed and the results will be low. In this connection it is to be noted that the chlorine dioxide is actually determined by a difference and that the calculation is such that any error is multiplied by a factor of five.

Perhaps even a more serious shortcoming is the fact that dichloramine and nitrogen dichloride will also be destroyed at this high pH. Since dichloramine particularly is frequently present in substantial concentrations, results for chlorine dioxide can be quite high. It is possible to indicate the presence of chlorine dioxide in this way, when actually none is present. This is an important point to keep in mind in considering persistence of residual chlorine in distribution systems. There have been reports that the use of chlorine dioxide causes residual chlorine in some form to be carried farther into the distribution system. In the work of Marks, Williams and Glasgow (5) it was shown that as the water goes out through the distribution system, the proportion of dichloramine increases.

Since residual bromine in water liberates iodine from potassium iodide, the titration of total available bromine can be carried out just as for chlorine. It is only necessary to keep in mind that bromine has a different atomic weight from that of chlorine, so that a different factor is employed in the calculation.

At present there is no way of utilizing this method to distinguish between free and combined bromine. Free available bromine is titrated by phenylarseneoxide without the addition of iodide, just as is free available chlorine. On the other hand, bromamine also titrates to some extent with phenylarseneoxide under the same condition. The rate at which bromamine reacts with the reagent is very much less than free available bromine. Because of this it is possible to make an estimation of how much of the bromine is free and how much is combined. When the point in the titration is reached where all of the free bromine has been titrated, the reaction of the cell to further addition of reagent is very much less marked. However, under most circumstances the end-point is not clear-cut and a precise differentiation

is not possible. For this reason, when residual bromine is to be measured, it is recommended that potassium iodide be added and only the total residual determined.

Summary

(1) A polarized electrode has been adapted to serve as an electrometric end-point indicator in the titration of available halogen in water.

(2) This method is inherently less subject to errors than a method based on a color change.

(3) Of greatest importance is the increased latitude in selection of titrating reagent and method to yield more detailed information.

(4) By titrating with standard phenylarseneoxide, solution under the proper conditions of pH and iodide concentration, it is possible to differentiate between free and combined available chlorine and between monochloramine and dichloramine.

(5) The method has been applied to the differentiation between chlorine dioxide and other forms of residual without complete success. This has important practical implications.

(6) The method is satisfactory for determining total available bromine residual but is not precise in differentiating free from combined bromine.

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LAYING SUBAQUEOUS PRESSURE MAINS

BY STEPHEN HASELTINE*

[*Read December 21, 1950.*]

Almost every water-works department faces or has faced the necessity of laying a water main across a body of water. This raises the question as to whether to go over or under the waterway, be it brook, river, pond or harbor. Much has been written about both courses of action. The intent of this paper, however, is to cover one field of the subaqueous method which has not received much attention.

Most of the material published concerning the laying of subaqueous pressure mains has covered those instances where it was possible either to utilize heavy floating equipment for placing the pipe or to build a cofferdam and lay the pipe in a dry trench. In some cases pipe-lines have been floated and sunk into place. In most of these instances pipes with lead joints were used, which required additional calking by a diver after the pipe was placed. Tests of pipes so laid often indicated leakage much above that allowable.

The projects described in this paper involved laying pressure mains across inland waterways only and the use of two methods. The first method was that of hauling into place the pipe-line as one complete unit; the second method covered floating the complete pipe-line into position and sinking it into place. In each instance a flexible-joint pipe capable of a 15-degree deflection was used.

The flexible-joint pipe has a ball-and-socket joint. The socket is flanged. After the ball on the spigot end is inserted in the socket, a rubber gasket, split ring and follower ring are brought into place and the socket flange and follower ring are bolted together with tee-head bolts. The ball, socket, split ring and follower ring all have machined surfaces. The ball surface of the spigot end is lubricated with a thin film of grease before joining. The ball-and-socket arrangement permits a maximum deflection of 15°. The bolts are tightened in pairs, 180° apart, by means of a 75-lb pull on a 19-in. wrench.

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At Concord, Mass., a 12-in. water main was laid across the Assabet River in September, 1948. At the point of crossing, the river is not navigable, but it is 50 ft wide and 6 ft deep at normal high water. Elevations were taken along the center line of the trench location and a profile was established, so that the maximum deflection of the pipe would not be exceeded and to allow for 2 ft of cover over the pipe. Bar soundings showed coarse sand and gravel for at least 5 ft below the river bed. It was necessary to use 10 lengths of pipe to bring both ends of the pipe above high water. One length was cut in half and one half-length was placed at each end. A sleeve and tapped plug were placed on each cut end and clamped back to the nearest joint.

The trench was excavated approximately 4 ft deep and 5 ft wide by a crane rig, with a dragline and drag bucket. The excavated material was placed beside the trench within reach of the crane rig. Due to the steep slope on one side of the river, a small truck crane with dragline equipment was employed to excavate the trench on that side. Before placing the pipe, soundings were made along the trench, to be certain that the maximum deflection would not be exceeded.

The complete pipe-line was jointed together on one shore and the total weight of 15,000 lb was hauled into place by the large crane rig on the opposite shore (see Fig. 1). The truck crane assisted the hauling by lifting the pipe at every other joint as the pipe started down the sleep slope from level ground. Once in place the pipe was subjected to an 80-psi air test, but no air bubbles were visible. The placement was inspected by probing around the pipe with a boat-hook from a rowboat. The pipe followed the profile of the trench very closely and no excessive deflection was discovered. The trench was backfilled immediately. A 24-hr test at normal water pressure of 60 psi showed leakage amounting to 7.5 gal. The complete operation took three days—three truck-crane days, one crawler-crane day, and 6 man-days.

Immediately following the Assabet River project, a similar crossing on the Concord distribution system was made at the Sudbury River. At the point of crossing the river was navigable for small power craft. The width was 70 ft and the depth about 10 ft at normal high water. The depth was only about 5 ft at the time the crossing was made. Twelve lengths of pipe were used to keep the ends above high water.

FIG. 1.—HAULING 12-INCH PIPE AT ASSABET RIVER CROSSING.

The placement of the pipe was accomplished as in the case of the previous crossing and took about the same length of time and equipment. The normal water-pressure test in this case indicated a loss of only 0.6 gal per day.

In April of 1950, 620 ft of 8-in. pipe were floated into position and sunk into place across Whitins Pond in Northbridge, Mass. (see Figures 2 and 3). In this case, it was not necessary to excavate a trench, except at each shore. A profile on the center line of the pipe location had indicated the bottom to be uniform and that the maximum allowable deflection of the pipe joint would not be exceeded.

FIG. 2.—HANDLING 8-INCH PIPE AT WHITINS POND.

Here the contractor elected to assemble 8 rows of six 12-ft lengths of pipe on cribbing, parallel to a 2-rail track. The rails were spaced 8 in. apart and bolted to planking, providing a ramp for the pipe to slide into the pond. Two 55-gal drums were attached to each length of pipe, to provide buoyancy. The pipe was hauled into the pond by means of a wire cable from a tractor-winch rig on the opposite shore. After each 72-ft section was hauled into the pond, a tapped blank flange was bolted on the last bell and a 150-psi air-pressure test was made. An inspector in a boat observed the last six joints, to detect air bubbles. It took four hours to assemble the eight 72-ft sections

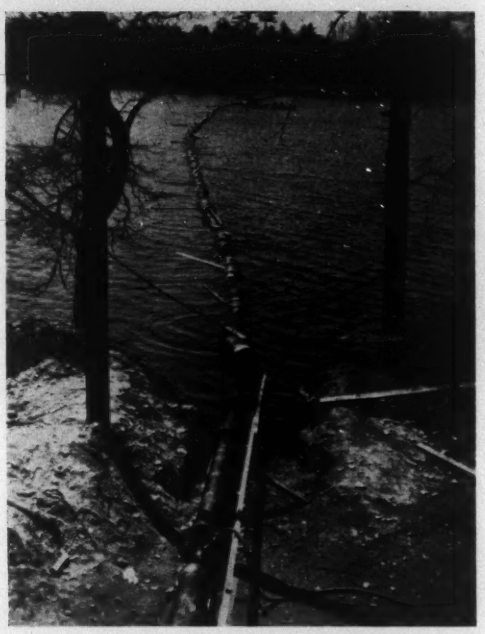

FIG. 3.—FLOATING 8-INCH PIPE AT WHITINS POND.

and float them into position. While one joint was being bolted, the 12 drums were attached to the pipe. Preparations had been made in advance and it was a well-organized operation.

The releasing of the drums was more difficult than had been anticipated, however. Each pair of drums was lashed to the pipe with a 30-ft length of ⅜-in. rope. The lashing around each drum was held by wire bag-ties. Small eyes were formed in the rope, 10 ft from each end, by means of the wire ties. The free end was wrapped around the drum and pipe and was slipped through the eye and lashed back on itself by means of another wire tie. The slack in the rope between

the drums was fastened to an 8-ft length of 2-in.-by-4-in. timber, which provided a buoy to locate each pair of drums as the pipe was lowered into position.

The plan called for cutting the wire tie on the free end with wire cutters and pulling on the timber buoy to release the drums. This became increasingly difficult as the pipe was lowered into position in deeper water, since the weight of the unsupported pipe lowered the drums so much that it was almost impossible to cut the tie on the drum. When the drum was finally cut loose under these conditions, it shot to the surface with great force, endangering the cutter. After much experimenting it was noted that the drums would not release immediately after the wire tie was cut but would hold, due to the friction of the rope as it passed through the small eye which was part of the hitch used. From this information, a plan was devised to cut the ties on the remaining 80 drums before attempting to release them and then pulling on the timber buoy at each pair of drums. This worked out very well for placing the pipe in position, but the reclamation of 80 drums, floating before a 15-mile-an-hour breeze, was somewhat of a chore for 12 men in 6 rowboats. Four drums and 2 men in one rowboat definitely created a crowded condition. Considerable skill was required to reclaim the drums and have only two boats overturn.

In August, 1950, a 20-in. pipe was laid across Omega Pond in East Providence, R. I., as part of the Blackstone Valley Sewer District Commission's construction program. This sewer force main at the pond was 300 ft long and was placed in the shape of a bow (see Figures 4 and 5). This unusual placement was made necessary in order to avoid heavy rock riprap, lying on the pond bed between the two shore lines. The location of the riprap was determined by taking bar soundings at frequent intervals where the pond bed had been cross-sectioned. Omega Pond was created by the construction of a dam across the mouth of Ten Mile River and is 9 ft deep at the midpoint of the pipe crossing. Since interference with the pipeline was remote, the pipe was not placed in a trench. A profile, plotted from the data obtained by cross-sectioning the area, indicated that the pipe-line could be laid on the pond bed without excessive deflection. It was necessary, however, to excavate a trench at each shore line, to provide 4.5 ft of cover.

Since one end of the pipe-line was located laterally within 10 ft

FIG. 4.—FLOATING 20-INCH PIPE AT OMEGA POND.

of the shore line, little working space being thus provided, the contractor cleared the area and filled along the edge of the pond. This furnished a level working space about 40 ft wide and 200 ft long. The trench at each end was excavated and, on the shore where the working area had been provided, a two-rail steel track, approximately 90 ft long, was laid from a point 20 ft in the pond back onto the shore.

The track consisted of 2 rails, spaced 24 in. on centers and spiked to ties of 2-by-8 timber. The ties were spaced approximately 3 ft apart. The pipe cradle was made of two 6-by-6 timbers as cross-pieces, resting on the rails and connected by two 2-by-6 timbers on the underside. The 2-by-6 timbers were 6 ft long and spaced to fit inside the track rails, to serve as guides to keep the cradle on the rails. Two-by-six blocks were spiked on top of each crosspiece at the ends, to prevent the pipe from rolling. The track rails and the underside of each cradle crosspiece were greased, to overcome friction as the pipe was hauled into the pond.

One at a time, five lengths of pipe were lifted by a crane rig from storage cribbing, parallel to the track, to the cradles in position on

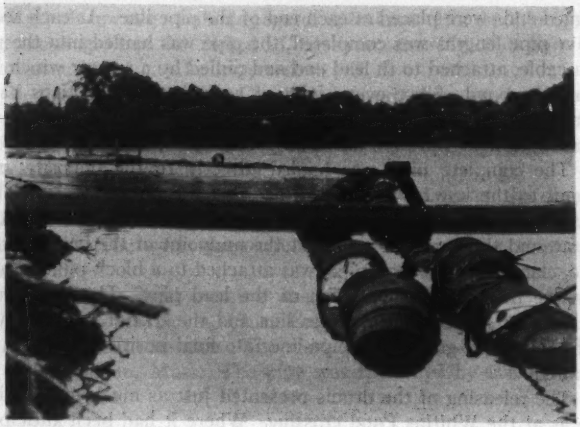

FIG. 5.—CURVED ALIGNMENT OF 20-INCH PIPE AT OMEGA POND.

the track. After placing the pipe accessories over the spigot ball and greasing the ball surface, the pipes were barred into position and the flanges bolted together. After each joint was bolted, three pairs of 55-gal drums were placed along the pipe barrel. Each pair of drums was wired together so that the wire, resting across the pipe barrel, held them in position. The drums were lashed to the pipe with ⅜-in. rope. The rope was placed around each drum and under the pipe, to form a saddle. Two ropes were used on each pair of drums. The ends of each rope were tied together by passing one end through the eye of a bowline knot, tied in the other end and making a hitching-tie. This arrangement was developed as an improvement over the use of wire bag ties on the Whitins Pond crossing. It was expected that, by pulling on the free end, the hitching-tie would untie, the free end would pass through the eye of the bowline, and the drums would be released tied togther by wire in pairs, a very simple and efficient arrangement to say the least, or so it seemed in the planning stage of operations.

As in the previous projects, one length of pipe was cut in half and a sleeve and plug were leaded on each of the cut ends. These

plugged ends were placed at each end of the pipe-line. As each section of five pipe lengths was completed, the pipe was hauled into the pond by a cable, attached to th lead end and pulled by a tractor winch from across the pond. Since every joint of each five pipe sections had to be made before the pipe could be hauled into the pond, 2½ days were required to float the pipe-line into position.

The complete pipe was hauled directly to the opposite shore, tangent to the bow at the shore line where the pipe was assembled. At that time the hauling cable was released and clamped to a cable ring around the barrel of a pipe at the midpoint of the bow. Another cable, clamped to the lead pipe, was attached to a block pulley, lashed to a tree near the final position of the lead pipe. The block-pulley arrangement hauled the pipe into line and the tractor winch, hauling at the midpoint, guided the pipe-line into final position, where it was anchored.

The releasing of the drums presented just as much of a problem here as at the Whitins Pond crossing. Where it had been anticipated that, once the hitching tie had been pulled loose, the end would pass through the eye of the bowline, such was not the case. The weight of the pipe was so great that the eye of the bowline was closed tight and the free end of the rope would not pass through. Several time-consuming methods proved of no value. Finally, a sharp chisel was bolted to a 10-ft piece of strapping. The chisel was placed against the rope around the submerged drum by a swimmer, while the handle was held by a man in a rowboat. After the swimmer was out of the way, the man in the rowboat jabbed the chisel, cutting the rope and releasing the drums. This was too slow, since two cuts were required to release each pair of drums. Therefore, one rope was cut at each pair of drums on the surface. The drums tilted at an angle, but were still firmly secured to the pipe. Then, as the chisel technique was applied, each pair of drums shot to the surface, causing the man in the rowboat considerable concern. As a matter of fact, one pair of drums rose directly under the boat, causing the boatman to dive into the water as a result of losing his balance. It was a slow process, but at the end of two hours all drums were released. One redeeming feature was the breeze, which blew most of the drums directly to the shore where they had been assembled.

Records are not available regarding leakage tests on either of the pond crossings, but the record of the river crossings is a fair indication as to what can be expected.

Acknowledgment. The Concord river crossings were constructed under the direction of John H. Robinson, Superintendent of the Concord Water Department. The work was performed by The Dingley Contracting Co., Natick, Mass.

The Whitins Pond crossing was constructed under the direction of Delwyn K. Barnes, Superintendent of the Northbridge Water Department. The work was performed by R. H. White, Contractor, Auburn, Mass.

The Omega Pond crossing was constructed under the direction of Charles W. Hammann, Chief Engineer of the Blackstone Valley Sewer District Commission. The work was performed by Gil Wyner Co., Inc., Malden, Mass. The pipe was furnished by the U. S. Pipe and Foundry Co.

RECENT SURVEYS IN CONNECTICUT OF WATER PIPING WITHIN BUILDINGS

BY CHARLES H. LAWRANCE*

[*Read January 18, 1951.*]

Realizing the importance to public health of proper sanitation of distribution systems of public water supplies and of water piping on consumers' premises, the Connecticut State Department of Health has, since 1937, carried on a survey of interior water piping in the larger towns and cities of the state, in coöperation with local health departments. The field work is generally done in the winter and early spring months, when outside activity is normally curtailed. The survey has proceeded, with occasional interruptions, until at present all the larger towns and cities of the state have been at least partially covered, while many have been covered completely and some have been, or will soon be, covered for the second time. The purpose of this survey is to uncover and eliminate any potentially hazardous piping connections within buildings, which might contaminate the drinking water. Within any community being surveyed, the inspections are confined to the limits of the distribution system of the public water supply.

The subject of cross-connections and other undesirable water-piping arrangements has received increasing interest and recognition in recent years by the water-works profession, as well as by health authorities. In February, 1945, Messrs. Scott and Wiggin of the Connecticut State Department of Health presented papers before this association on the respective subjects of "Responsibility for Water Piping on Consumer Premises" and "Survey of Interior Water Piping in Connecticut", and there have been other discussions as well, along this line. However, while cross-connections and inter-connections between the public water supply and a private secondary supply are quite familiar to water-works men, there are two other general types of connections which perhaps receive less consideration.

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Types of Hazardous Water-Piping Connections

One is the so-called submerged inlet or back-siphonage connection and the other is the direct sewer connection, neither of which involves any other water-supply source than the public supply, but both of which can be hazardous.

A back-siphonage connection consists of a direct water-piping inlet into a tank, vat, swimming pool, plumbing fixture or other liquid container, where the inlet itself is submerged beneath the normal or maximum level of liquid in the vessel. Frequently, as in the case of many rinse tanks in electroplating establishments, the public water is allowed to flow continuously into the tank. If the public water-supply pressure were to drop suddenly, due to hydraulic conditions within the building or within the street main, the flow might be reversed and the contents of the tank be siphoned out into the public water-supply system.

A direct sewer connection occurs where a waste water line from a piece of water-cooled or water-operated equipment, or a certain drain pipe from a water tank, is connected directly to a sewer. The waste water from the device or fixture normally flows away through the sewer. The danger with such a connection is that if the sewer becomes plugged or surcharged, flow may "back up" into the water-supply line or tank. Also, the flooding of a device or fixture by the backing up of a drain or overflow pipe may submerge the water inlet with waste water or sewage.

The potential hazards from a cross-connection or arrangement involving the direct physical connection of piping of the public water-supply system with that of a private well, pond or canal supply need no elaboration. However, it is pointed out that in some cases we consider a cross-connection to exist, even though there is no other source of water supply involved, but where there is a forced circulation of solution, as is found in some types of industrial equipment. In making the survey, we also look for drinking-water storage tanks that may be improperly located as far as flooding or overhead sewers are concerned, or which might otherwise be exposed to contamination. Such tanks are rarely encountered.

The Connecticut Sanitary Code regulations cover all undesirable

water-piping connections fully and prohibit them. We recognize that the actual degree of hazard with any particular connection may be a function of local conditions. With some, the dangers are quite real and apparent; with others, the dangers may require the right combination of circumstances to be present; with a few, the hazards may even be fairly remote. Our general policy is to require conformance with the Sanitary Code regulations and we work in coöperation with the local water utilities for the immediate elimination of the more serious types of conditions found—such as cross-connections—while we ask the coöperation of the local health authorities in eliminating the remainder of the undesirable connections found, giving priority to those considered most serious.

Survey Procedure

In making the water-piping survey, an engineer from the Bureau of Sanitary Engineering of the Connecticut State Department of Health has first contacted the local health officer, as well as the superintendent of the public water utility, to explain the objectives and limits of the survey to be made. Following this, the survey has been made by the engineer, accompanied by a local health-department sanitary inspector usually, and occasionally by a water-utility representative. The inspections here included: all factories and industrial establishments, laundries, theaters, hotels, bottling plants, pasteurization plants, buildings over three stories in height and stores with two or more stories. The multi-story buildings have been included because of the greater possibility of encountering water tanks for maintenance of pressure on the upper floors and, in some instances, for hydraulic-type elevators. The surveys have included all stores or buildings having air conditioning as well. During the past three winters, the survey has covered six towns and cities. All the communities have been industrialized to at least some degree. For five of the communities, the average population was nearly 40,000 persons, while that of the sixth was about 100,000 persons. In the case of one community, the local newspaper, having gotten wind of the impending survey, gave it some free advance publicity and helped pave the way for the inspections. This was probably the exception rather than the rule. We like to inform those who will be involved with the inspections as to what the

inspection will be concerned with and what its purpose is, for, after all, one of the purposes of the survey is education of the populace. We also are sure to visit each local newspaper during the course of the survey, if not at its start. Sometimes we find some piping condition in need of correction at the newspaper building itself and, therefore, we cannot always count upon the immediate enthusiasm of the newspaper.

Since a separate and special survey of water piping and other equipment in all public and private hospitals in the state was completed recently by our housing engineer, hospitals, as well as public swimming pools and sewage-treatment plants, which are regularly inspected anyway, have not been included in our general water-piping surveys.

There are many types of equipment, involving the use of water, that are quite common and some of the most simple may be the most hazardous. For example, in electroplating establishments, the various water-rinse tanks into which water is run, usually continuously, may receive drippings of cyanide, acid, alkali, or metallic salt solutions from the work, a submerged inlet thus being very hazardous. In the case of many air compressors, refrigeration equipment and other water-cooled equipment, cooling water is frequently left running continuously, and hence a direct sewer connection may be particularly hazardous. Occasional sewer-flushing connections are found, and priming lines to non-potable water or liquid systems are rather common and can be dangerous.

We often employ a simple and somewhat lengthy list of sample types of equipment, involving the use of water, in which we are most likely to be interested. We do this in order to facilitate explanation of the nature of the survey to an official of a concern such as a factory. If the display of prepared sample sketches of certain piping connections seems warranted, then we use these also, along with the verbal explanation, to prime the official sufficiently as to our purpose before proceeding with the inspection. We ascertain first of all what other water-supply sources there are besides the public supply, if any, and then what the source or sources of water are for the general uses of drinking, hand washing, toilet flushing, process, boilers, and fire protection. The inspection then proceeds, with coverage of all do-

mestic and fire services; auxiliary sources of supply with pumps, tanks and appurtenances; provisions for alternating sources of water supply for convenience or emergency; potable water-storage tanks; all equipment that is water-operated, water-cooled, water-supplied, or otherwise involved with the water system or systems. Complete tracing of all piping is often not practicable, but the procedure used has been found effective in locating all undesirable piping connections, we believe.

Findings

A tabulation of the findings of the survey for the latest six communities covered appears in Tables 1 and 2. Before citing some actual examples of piping arrangements and conditions found, a few figures will illustrate the scope of the survey and the general state of affairs. In the six communities, 569 locations were inspected, but only slightly over 14% of all these locations had an auxiliary source of water supply. The total number of active cross-connections involving a non-potable water supply was 62, or about 10 per town, and these were concentrated in only about 4½% of the total locations visited. The submerged inlets or back-siphonage connections totaled 393, being found in about 23% of the total places visited. The direct sewer connections came to a total of 136 and were found in about 17% of all the locations. Inactive cross-connections or inter-connections with potable water supplies were also recorded, but will not be included with these figures. Of all the locations inspected, those having nothing whatsoever wrong in the way of water piping came to 61% of the total. If any one class of locations could be singled out as being most responsible for poor findings, it would probably be the factories, with the laundries a fairly close second.

Cross-Connections Found and Corrective Measures

Many of the actual findings were what would be expected, while some were rather unusual. We more or less expect to find at least one cross-connection in large industrial plants with heavy water demands and an auxiliary source of supply, and we are not disappointed in this respect in many cases. This is true despite the fact that the larger of the companies are likely to be the more aware of the dangers of cross-connections, more alert to guard against them, and most coöperative

TABLE 1.—SUMMARY OF LOCATIONS OF INTERIOR WATER-PIPING SURVEY INSPECTIONS IN SIX CONNECTICUT COMMUNITIES

Town or City	A	B	C	D	E	F
Population—Advance Figures, 1950 Census	33,906	40,546	29,665	44,401	43,747	104,242
Factories Inspected	51	20	27	42	56	69
Theatres Inspected	2	2	3	2	3	6
Laundries and Dry-Cleaning Establishments Inspected	7	6	10	0	5	7
Pasteurization Plants Inspected	5	0	1	2	18	4
Bottling Works Inspected	1	0	1	1	3	2
Hotels Inspected	0	10	1	0	2	6
Other Buildings and Stores Inspected	10	1	23	4	45	121
Total Locations Inspected	76	39	66	51	132	205

TABLE 2.—SUMMARY OF FINDINGS OF CONDITIONS NEEDING CORRECTION IN SIX CONNECTICUT COMMUNITIES

Town or City	A	B	C	D	E	F
Locations Having Auxiliary Water-Supply Sources	17	5	4	5	16	34
Cross-Connections Active	6	2	10	17	9	18
Broken, but Potential, Cross-Connections	3	2	1	37	2	8
Direct Sewer Connections	15	6	43	19	28	25
Submerged Inlets	13	63	92	45	94	86
Inter-connections with Potable Supplies under Separate Supervision	1	0	1	0	7	1
Total Number of Conditions Needing Correction	35	71	146	81	138	130

in eliminating any such connections uncovered by the survey. In one textile plant whose management has always been most coöperative, we recently found one six-inch cross-connection between the potable water supply and a non-potable pond supply, a second point of temporary but periodic cross-connection between the two supplies, and two rather similar cross-connections between the potable water and process solution at a skein-washing machine and a dyeing machine,

at the points where the make-up water entered the respective pumped-recirculation systems. In view of the magnitude of the water piping in the plant and consequent opportunity for cross-connections, conditions might have been a lot worse. The management corrected the cross-connections promptly, eliminating the active cross-connection by means of a so-called swing connection, whereby the distribution piping can be supplied separately, but not simultaneously, from the two respective sources of supply. Although not completely ideal, this corrective arrangement is the most completely fool-proof and generally satisfactory method of providing for use of two different water supplies without cross-connection.

The ideal arrangement of separation of supplies is, of course, to supply a tank from the respective sources, with the potable water supplied by an above-the-rim inlet, and then to distribute this water as desired by gravity or by pump. This arrangement is always recommended in the case of new proposed installations and many plants have such a set-up.

The temporary cross-connection arrangement at the textile mill was eliminated by means of a single spool-piece for use across either of two identical, valved open gaps in the piping, provision thus being made for separate but not simultaneous use of the two sources of supply. The make-up connections to the washing and dyeing machines were broken off from the pressure re-circulation systems and were simply allowed to discharge openly to the solution tanks from a point above the flow line, in order to prevent submergence of the water inlets. Where a pressure recirculation-type piece of equipment has a potable-water connection for pump-priming purposes, this can usually be corrected by letting the water be discharged through an open funnel, placed in the priming line above the level of the pump.

The multiplicity of types of water-supplied equipment is such that we are continually running into new things with each survey. One ball-bearing plant had a number of ball-grinding machines, each with a soluble-oil recirculation system, and each of these was supplied with a separate priming connection from the public water supply. A brine-recirculation pump in another plant was found to be similarly primed. Occasionally paint-spray booths have a recirculated water curtain, which may have a cross-connected priming connection or a submerged

inlet for make-up water. Such findings are not necessarily confined to the industrial zones, but may even crop up on downtown Main Street. At one store-and-office buiding and at one bank we recently discovered improvements had been made for the comfort and convenience of the public during winter days in the form of sidewalk-defrosting systems. These involved a forced-circulation system of preheated alcohol solution in pipe coils under the sidewalk, and in each case a direct public-water-supply make-up connection to the system was provided. In one factory a cylinder unit containing a wetting agent which is a toxic compound was found in direct connection with the public water-supply system. This was being used in conjunction with an obsolete dust-collection system.

On the more routine side, one of our engineers found a cross-connection at one industrial plant between the public water supply and a non-potable river supply, where the pumped river supply was supposedly "separated" from the potable supply by a valve, although in this case the valve was found open. What made this particular connection doubly dangerous was that the *normal* operating pressure of the river supply exceeded that of the city water pressure at the plant, and hence some actual backflow must have occurred into the potable-water piping system. Fortunately no cases of resulting illness were reported. Needless to say, the cross-connection was broken immediately. Circumstances such as this bring out the element of human error, if valves are to be counted upon for separation of water supplies from each other. Knowing that all valves, including check valves, are subject to leakage at one time or another, we do not accept any type of valves as satisfactory for separation of water supplies, except that properly constructed and periodically inspected, double check-valve installations have been allowed to continue in service under permits when they were in existence on December 31, 1926, at which time the state regulations on cross-connections were adopted. Other findings deserving passing mention might be those few wells whose existence was largely unsuspected and which were found in the heart of some of the down-town areas. A few were cross-connected with the public water supply and, although some were considered potable, there is no significant supervision of such private wells from the sanitary standpoint, in most cases.

Back-Siphonage Conditions and Corrective Measures

With regard to back-siphonage connections, a sizeable portion of these are still found from time to time in industrial electroplating rinse tanks, although progress has been made in the education of plant officials as to the potential hazards involved. In more than one plant the plating room has been located on the upper floors, sometimes as high as the third or fourth story. This, of course, increases the dangers from submerged inlets. In my own experience, for a few months I had the misfortune to find my post-war housing in a small, third-story attic apartment, where the water piping was of inadequate capacity and where, upon certain occasions, I could easily have siphoned water from a tumbler back through the faucets at the sink, had I so desired.

In laundry equipment, virtually all of the older models of washers are equipped with submerged water inlets. Most of the newer models seem to have had the water inlets raised to a point which is at least above the normal operating water level. There is still room for improvement in the design of laundry equipment from the standpoint of water-piping connections, and the same can be said for many other common types of dairy and industrial equipment, such as bottle- or container-washing machines and even dish-washing machines for restaurants and hotels. Efforts have been made to persuade manufacturers of certain types of equipment supplied by water to avoid design features which would be undesirable from the sanitary standpoint. With regard to laundry washing machines, automatic valves are usually provided on the water-inlet lines, while in the case of quench tanks, photographic rinse tanks, chemical vats, water pans of air-conditioning units and the like, manual valves may be used on the inlet lines. Some measure of protection is doubtless provided by certain types of valves, but in accordance with the Sanitary Code and our policy regarding cross-connections, we do not accept this as sufficient and require elimination of submerged inlets by making the water inlets terminate a minimum distance above the maximum flow line. If it is inconvenient to do this because of the design of the equipment or if it is preferred to have the type of circulation of water in the tank which is obtained with a submerged inlet, then an air break must be inserted in the water line at a sufficient distance above the flow line, an open funnel being utilized, or discharge is made into an over-

sized pipe or a commercial vacuum breaker of an approved type is installed.

Direct Sewer Connections and Corrective Measures

In the case of direct sewer connections, the industrial districts have no clear monopoly on the number of undesirable conditions found. Of course there are always the water-cooled air compressors, high-frequency induction furnaces, plastic annealing tanks, chemical reaction tanks, spot-welding equipment, degreasers, hydraulic jacks and the like, which are more or less common to the factories. However, water-cooled equipment for refrigeration and for air conditioning is found also in the commercial districts, as are occasional hydraulic elevators and hydraulic sump pumps. Fire sprinkler systems are significant generally from the standpoint of drains and testing blow-offs in the manner of connection to the sewer. In the industrial districts, the normal way is simply to discharge the flow onto the ground outside the buildings and thereby eliminate any consideration of sewer connections. However, this is not usually possible in the built-up commercial areas and hence most fire sprinkler blow-offs and drains are likely to find their way directly to a sewer, contrary to Sanitary Code regulations.

As with other types of direct sewer connections, we ask for introduction of a definite open break in the waste-water piping, leading to the sewer, and, in cases where discharge to the outdoors is not feasible, discharge of the flow into an open tank, sink or sump, connected to the sewer. In many cases this can be done satisfactorily without excessive expense by the use of tanks improvised from oil drums. Introducing an open break in sprinkler blow-off connections before the sewer has the advantage of allowing the fire-insurance inspector actually to see the flow of water during the test, although some disadvantage may also be imposed by the capacity limitations of such a tank to receive flow for other than brief tests. We recognize that, due to conditions present, fire sprinkler-system connections directly to sewers would probably have to be subjected to an unusual combination of circumstances in order to cause contamination of the water piping, and hence such connections do not receive as high a priority of follow-up attention as do direct connections from compressors, refrigeration units and the like.

One aspect of fire sprinkler systems which does rate top attention, however, is the use of anti-freeze solutions in portions of sprinkler systems, such as unheated warehouses and storerooms. These are not common, fortunately. Usually a "dry system" is employed for such locations and this is definitely the best arrangement from our standpoint. However, we have uncovered two cases where the portion of the sprinkler system in question was filled with carbon tetrachloride, an exceedingly toxic substance, for anti-freeze purposes. The Connecticut State Department of Health recommends the use of no anti-freeze substances in fire sprinkler systems supplied from the public water supply, except that in special circumstances, where the local water utility agrees to the arrangement, chemically pure glycerine has not been objected to for such purposes.

That sewers and storm drains have been known to become surcharged is not a mere matter of speculation. One newspaper-publishing building was located on the lowest spot on the street, and in the basement of the building there was a cast-iron sewer with a few toilets thereon. There may have been illegal roof-drain connections to the street sanitary sewer or excessive ground-water infiltration to the same, or perhaps even some sort of unknown connection between the sanitary sewer and the storm drain. For whatever reason, at times of heavy rainfall and run-off, the street sanitary sewer would become surcharged and once or twice sewage actually backed through the building sewer and spilled over in the basement through the toilets. This caused the newspaper to go to the expense of installing a shut-off valve on their sewer connection, in order to protect their basement in times of heavy sewer flow. Also at this particular location, the printers used a sort of abrasive soap, to help clean their hands at the wash sink, and grit from the soap would collect in a second, similar building sewer, running under the basement floor. Thus, when this location was inspected, it was found that there was a direct, valved, public water-supply connection located in the basement of the building, which was used once per week to flush the grit out of this building sewer line. Fortunately, such connections are not very common.

At one factory there was a record of backing-up of flow through a waste-water drain onto the factory basement floor from a river at flood stage. In one city, where, due to expanding population and water

consumption, the sewer loads had begun to reach the sewer capacities, a public swimming-pool had its overflow gutters directly connected to the public sewer. Although there was never a known occurrence of the actual backing-up of sewage into the swimming-pool, the threat became real enough to cause the owners to break the direct sewer connection.

Miscellaneous Connections

One final illustration of unusual arrangements involving water piping would be the few isolated installations found for the addition of sulphuric acid to water piping from the public water supply at hat-manufacturing concerns. The purpose is to bring the pH value of the city water down a few tenths to that value which is considered optimum for particular parts of the hatting process, and to this end commercial sulphuric-acid solution is applied by various types of commercial solution-feed equipment. The pH-value range aimed at is from 6.0 to about 6.5, which is, of course, well within the range of such standards for potable water. Also, the acid added is in fairly dilute solution and in small, metered amounts. Careful control by the plant laboratories was being exercised and frequently daily pH tests were made. We required some minor modifications of certain connections or parts of the equipment, to guard against the possibility of back-siphonage, and also required that all drinking-water outlets and lavatories be supplied from a piping system separate from the one to which the acid was being added. The individual manufacturing plants concerned are being held responsible for the safe and satisfactory operation of these unusual installations.

Follow-up Procedure

Reference has already been made to the method of following up on the unsatisfactory conditions found by the survey. The Sanitary Code of the State of Connecticut enjoins public water utilities from supplying water to any consumer who maintains a cross-connection with an unapproved water supply. We therefore ask the water utility to follow up on the cross-connections we find, with subsequent re-inspection by the engineer from the State Department of Health. Interconnections with allegedly potable wells or other potable supplies are

also turned over to the water utility, while all other questionable or undesirable conditions are turned over to the local health authorities for future action. Generally, coöperation has been good, from water utilities, health departments and places inspected alike.

Our experience has indicated that considerable progress has been made in the last 10 or 15 years in the matter of improving water-distribution piping in buildings, but also that there still is a tremendous job ahead before conditions approach anything that might be considered perfect by water-works men and health authorities. This is borne out by our continued ability to uncover cross-connections, back-siphonage connections and direct sewer connections in any town we survey. This is because education is such a slow process and people naturally hate to borrow trouble if it is going to cause inconvenience or cost money. Then, too, in all of these undesirable piping connections, the right conditions must be present in order to have trouble. The public water pressure has to be exceeded by the pressure from the secondary supply or else has to be dropped, due to fire flow, flushing or a large break. The sewer has to be surcharged or the water pressure in the building piping has to drop drastically, due to corrosion-restriction of pipes or simultaneous use of a large number of fixtures. Valves have to leak or be left open by mistake. Such things are not usually easy for the layman to accept upon first offering. It takes a shocking experience to make an impression on people rapidly.

Such an occurrence did happen in one of our largest cities a few years ago. Public water mains became contaminated as a result of a temporary cross-connection with an unsafe river supply. Several cases of illness resulted. Since that incident, this public water utility has kept an inspector assigned full time to field inspection of water piping on consumers' premises in the distribution system and a number of undesirable connections have been eliminated.

Many other public water utilities in Connecticut carry on active inspection work on consumers' premises, although generally not on quite as exhaustive a scale as that of the water utility just mentioned. Some utilities have meter-readers trained sufficiently to be able to look for and recognize cross-connections. Some have distribution-system inspectors engaged in looking for leaks and illegal connections to service lines. These men are able to devote a portion of their time

to looking for cross-connections and other undesirable connections. One utility, serving an industrial community and finding itself unable personally to inspect water piping in most of the factories, has the plant management send the utility an annual letter, with a statement to the effect that to the best of the knowledge and belief of the management there is no cross-connection within the water piping of the plant. Many utilities keep files of locations having auxiliary sources of supplies. In the case of the utility with the full-time water-piping inspector, an added advantage has been found for having this man on the job. Now that his initial survey of the distribution system has been completed, he is able to spend part of his time in checking on proposed new service and meter installations, prior to actual installation, and thereby saves the utility and its distribution-system men and meter-readers a lot of potential future grief. So far as this goes, many water utilities have rather extensive regulations pertaining to water-piping connections, sometimes duplicating certain provisions of the State Sanitary Code.

One thing that should be brought out while on the subject of rules and regulations is that a number of the larger municipalities have plumbing codes, including some of the cities mentioned in this survey. These codes deal almost exclusively with waste-water piping without mentioning water-supply piping, which is, of course, equally important from the standpoint of public health. Even where these codes have been in active use, occasional violations have turned up in the form of direct sewer connections. The codes vary in completeness and some types of sewer connections may not be covered at all. The Connecticut community having the full-time water-piping inspector referred to also has for some time had incorporated into its plumbing code a section relating to pollution of water supply by sewage; the provisions are sweeping enough to make practically all types of direct sewer connections illegal. Yet this inspector uncovered over 100 fire-sprinkler blow-off or drain connections to the sewers. It is, therefore, apparent that the plumbing profession must be won over, and that somehow the plumbing codes must be made more extensive and made to cover water-supply piping as well as waste-water piping. Any publicity work that a water utility can carry on with its consumers, to promote understanding of the hazards of certain types of piping connections

and the need for their elimination, should be all for the good. The Connecticut State Department of Health, in coöperation with a committee of the Connecticut Water Works Association, has drawn up a proposed local ordinance or regulation, covering water-supply piping installations, which may be adopted by a local community or made a part of its plumbing code.

Summary

The subject of cross-connections and other undesirable water-piping connections on consumers' premises, involving a public water supply, is one of direct concern to the public health and to public-health authorities. There is no disputing the fact that the public water-supply utilities are also directly concerned in all cases where piping conditions on a consumer's premises may possibly cause contamination of the water in the street main under normal operating conditions. This should also be extended to include "abnormal operating conditions", such as when the public water-supply pressure drops drastically. Although not common, large breaks or fire flows have been known to drop water pressure badly. Unprotected hot-water storage tanks in buildings have been known to collapse from such conditions. Whether or not the water utility considers itself responsible for the safety of the water from the source to the ultimate and free-flowing outlet of the individual consumer, a water utility must make and enforce certain regulations regarding consumers' piping connections, in order to protect the water in the city main.

Hence there appears to be a joint responsibility for water piping on consumers' premises between water utilities and health authorities. The fact is, however, that neither the water utility, the local health department, nor the state health department has unlimited time to devote to surveys and inspection work. The state health department shares responsibility for all the public water supplies in the state, but cannot physically inspect each system thoroughly. The local health departments are small, generally, and, even if they have inspectors available, they lack the considerable training necessary to perform this type of work. The individual water utilities have only one water-supply system apiece to worry about, but they have their hands full with other aspects of operation. The problem becomes a local one and

even a community one; if adequate local ordinances can be enacted, the problem is much easier. It may be easier for the state health agency to initiate a program of thorough piping inspection in a community than for either the local health department or the local water utility. The state health department can also give assistance to some extent to local health departments and water utilities on follow-up work, once such a survey has been made. But the state health department cannot stay forever with the system and perform the continuous amount of work that can be done only on the local level. Probably, of all the local agencies, the public water utility is most familiar with the problems and in the best position to appreciate their seriousness. Therefore, the local water utilities should assume their rightful share of leadership in these matters on the local level.

FACTORS INFLUENCING THE EFFICIENCY OF ACTIVATED CARBON

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[*Read January 18, 1951.*]

Powdered activated carbon was first used to control disagreeable tastes and odors in public water supplies by George Spalding of the Hackensack Water Co., New Milford, N. J. Since the introduction of activated carbon into this plant in 1930, its use has steadily increased, until approximately 1,300 plants have used activated carbon for controlling taste and odor conditions.

The mechanism by which activated carbon is able to remove the taste and odor bodies is known as adsorption. Our knowledge of the ultimate nature of adsorption is limited, although evidence has shown that adsorption may be physical, chemical, electrical, or a combination of these. We, as practical operators, are not so much concerned with the nature of its action as with the benefits derived from its use. The primary interest to water-works operators is that activated carbon, through adsorption, can and will eliminate taste and odor conditions from water.

Numerous factors affect the efficiency of the carbon for adsorption, some of which are not within the control of the water-works operator, but others may be controlled. For example, the action of carbon is influenced by the contact period and chemical treatments. The latter influence is of particular interest to the water-works operator, since the chemicals used for disinfection or softening often produce changes in the taste-and odor-bearing substances. Methods of solving this type of problem can best be illustrated by typical examples.

Influence of pH

The efficiency of adsorption by activated carbon is influenced by pH. In Oklahoma City, decreased adsorption was noted at a high

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pH. Here, during a taste and odor survey, unsuccessful attempts were made to prepare odor-free water by passing the tap water through a granular carbon filter. Reducing the pH of this tap water from 10.5 to 7.5 made possible the preparation of odor-free water by this method.

Special attention is sometimes required when carbon is applied in plants which use lime for softening or pH adjustments. Frequently, at such plants, a change in the order of adding chemicals results in a more efficient action by the carbon. At Fergus Falls, Minn., 75 lb of activated carbon per mil gal removed 10% of the odor when the pH was 10.6. In contrast, the same dosage of carbon netted a 70% reduction of the odor when the pH was lowered to 9.6.

Some compounds, such as phenols, are difficult to adsorb at pH values above 8. An explanation for the decreased adsorption is sought in the fact that alkali converts the phenol to phenolate, the amount of conversion being proportional to the increase in pH. Since the salt of phenol is difficult to adsorb, a decreased adsorption follows an increase in the formation of sodium phenolate.

A few compounds, such as aniline or pyridine, are much more readily absorbed at high values for pH than at low values for pH. However, these compounds are rarely found in water supplies.

In so far as the water-plant operator is concerned, pH values around 8.5 or lower may be considered best for promoting the most efficient action of the carbon.

Contact Time

Adsorption normally occurs as soon as a carbon establishes contact with the taste and odor bodies. In the water plant, where the dosage of carbon is relatively small, longer contact periods are to be desired. Thus, at Oklahoma City, satisfactory adsorption of the taste and odor bodies by carbon was obtained by increasing the time of contact from 15 to 30 minutes.

Chlorine

It is almost universal practice to employ chlorine in some form or other for the disinfection of the delivered water. Many plants have used chlorine for controlling the taste and odors in the water with

varying degrees of success. Some plants have reported a decided improvement, whereas others have reported failures. A number of plants using super-chlorination, free-residual chlorination, or marginal chlorination for taste and odor control have employed a supplementary treatment with carbon, in order to produce a water acceptable to the public. To illustrate, in 1946, during an outbreak of *Asterionella* in an Ohio water plant, free-residual chlorination reduced the odor 40%; however, the operation changed the characteristic taste of the water and made it unpalatable. It was necessary to supplement the treatment with carbon to reduce the concentration of odors in the water to a satisfactory level.

Instances have been encountered where it was advisable to change from free-residual chlorination to marginal chlorination, to prevent the formation of chlorinated compounds, which were more obnoxious than those in the raw water. Thus, at Centralia, Ill., in 1948, the change from free-residual chlorination to marginal chlorination was effective in producing a final product acceptable to the public.

A city in Louisiana, in 1947, can be used to illustrate free-residual chlorination's changing the characteristic odor from grassy to woody without changing the intensity of the odors. However, there have been occasions when free-residual chlorination has actually intensified the odors. Threshold odor tests conducted in Chicago, in 1947, showed that the increased concentration of odors was due to the formation of chlorinated compounds. Further studies indicated that each pound per million gallons of free chlorine residual increased the threshold odor value 2 units over that of the unchlorinated water.

Other mutual effects of carbon with chemicals used for disinfecting water require consideration. For instance, chlorine and carbon have an affinity for each other, the chlorine adsorbed by the carbon being converted to chlorides by catalysis. It has been reported that carbon can adsorb 10% of its weight of chlorine and still remain effective for adsorbing tastes and odors. In so far as carbon is concerned, the decreased efficiency brought about by applying the two-chemicals together would be minor. However, the oxidation potential of the chlorine is reduced and some thought must be given to the point of application to prevent any possible interferences between the two chemicals, resulting in a waste of chlorine.

Frequently, it is to the advantage of the water-works operator to apply carbon after free-residual chlorination. This often enables the chlorine to accomplish some odor improvement and thereby reduces the amount of carbon required to produce a palatable water. Such was the case of a city in Ohio in 1947, during an algae condition, where free-residual chlorination, followed by carbon, was found to be more effective in removing tastes and odors than when either was used as a separate treatment.

In contrast, Hamlin, Tex., in 1948, illustrates an occasion when chlorination was detrimental to the action of carbon used subsequently. Here the characteristic odor was changed to an odor more difficult to adsorb than the original one. In this case, greater benefit was obtained by adding carbon prior to the chlorination.

Chloramines

The addition of ammonia to the water prior to the addition of chlorine often prevents the formation of malodorous compounds, resulting from the action of chlorine on the taste and odor compounds.

Three types of chloramines may be present in the water: mono- and dichloramine and nitrogen trichloride. Of the three possible forms of chloramines, the mono form is considered the least adsorbed by carbon.

Coagulation

Due to the proximity of the standby feed equipment and pipelines, the mixing basin is generally considered the most convenient point for applying carbon. Several advantages may be realized from this point of application:

1. Carbon may act as a nucleus, upon which the floc particles form.
2. Sludge is stabilized.
3. Caking of the sludge may be prevented and, consequently, the sludge can be hosed to the sewer.

In a few instances, e.g., Lawrence, Mass., in 1949, the floc formation has been found detrimental to the action of carbon. Here the floc was so heavy that the carbon was immediately taken up and subsequent adsorption of the taste and odor bodies was greatly reduced.

Adjusting this floc formation so as to give the carbon greater contact time resulted in an increase of 88% for the amount of odor removed.

Filters

The application of carbon to the top of the filters is recommended, so that a more positive contact may be established with the taste and odor bodies in the water. Moreover, a more efficient use of the adsorptive powers of carbon is realized.

An objection has been raised against this point of application—namely, that carbon may pass through the filters. In cases where carbon passes through the filters, the condition can be readily detected by the black color. However, when carbon passes through the filters, there is a good chance that other things are also passing through that cannot be seen; thus the carbon is really acting as a tell-tale. To correct such conditions, it becomes necessary to check the other operations in the plant. At East Chicago, the trouble was found to be caused by a weir, which was breaking up the floc and, as a result, alum as well as carbon was passing through the filter. At Fairmont, Minn., the size of the coal particles used as a filter medium was found to be too large to effect proper filtration. Inspection of the filter effluent showed the presence of alum floc as well as carbon.

Chlorine Dioxide

Until recently, when chlorine dioxide has been used, it has been applied to the waters of clear-wells for the elimination of medicinal tastes and odors. A short time ago, at a city in New York, chlorine dioxide was tried for the disinfection of the water. In the test, chlorine dioxide was applied to the settling basin. If chlorine dioxide is to be used for disinfection, we can expect that it will influence the selection of the point for applying the carbon, just as has been found when chlorine is used for disinfection.

The use of chlorine dioxide as a taste-and-odor-control agent may be best illustrated by citing several plant studies. At times, medicinal tastes and odors are received at the intake of a water plant in Kentucky. In 1948, studies at this plant showed that chlorine dioxide on a cost basis was more efficient than activated carbon for removing the medicinal taste and odor. However, on algae tastes and

odors chlorine dioxide had little or no effect, and for these, activated carbon had to be relied on to produce a palatable water. Tests at Appleton, Wis., in 1949 indicated that chlorine dioxide, applied to the clear-well, did not effect any reduction in the algae tastes and odors present, but rather was specific for phenol contamination which is encountered in the winter months.

In 1949, studies at Fergus Falls, Minn., showed that supplementary chlorine dioxide (0.6 ppm to 1.2 ppm as sodium chlorite), applied to the clear-well, did not extend the odor reduction beyond that already accomplished with activated carbon. Applying the chlorine dioxide to the raw water decreased the raw-water odor (swampy-type odor) from threshold odor number 14 only an average threshold odor number 12. Generally, the threshold odor number of the tap water should be 5 or less, to be considered palatable.

Handling Activated Carbon

Activated carbons, used in water purification, are delivered in a very finely divided state, the greater part passing a 325-mesh screen. This extreme fineness, combined with the low apparent density of the carbon, results in dusting and wetting characteristics which may be quite troublesome, unless preventive measures are taken.

Although some dusting occurs during the unloading of the carbon packages from the car, the greatest amount is encountered when the carbon is emptied from the bag into the feeding hopper. This may be minimized by suitable handling precautions and the scattering of any dust can be reduced by installation of dust collectors. Dust collectors usually operate on the principle of creating a partial vacuum at the hopper door, the escape of carbon particles to the room being thereby prevented.

When bag-type dust collectors are used, it is essential that the bags be cleaned frequently, in order to maintain maximum efficiency for the dust-collecting system. Portable dust collectors, equipped with a suction hose, are now available and can be used to pick up carbon that has been accidentally spilled on the floor or remove carbon dust that has accumulated over a period of time. A barrel or chute to a closed bin should be provided for disposing of empty carbon bags.

New methods of handling and feeding activated carbon have been

investigated and results show that carbon dusting can practically be eliminated by receiving carbon in bulk (closed hopper cars or trailer trucks) and using wet storage. Even where it is not feasible to receive bulk shipments of carbon, it has been found that wet storage has advantage over dry storage, especially for the elimination of dust. When a shipment of carbon is received, the bags may be emptied directly into the wet-storage tanks. Wet storage not only eliminates dusting during the application of carbon, but eliminates labor costs for moving carbon into storage and then out of storage to the carbon-feed machine.

The wet-storage tank should be equipped with an agitator, to maintain a uniform suspension at all times. Proportioning devices, such as Moyno pump, roto-meters and weirs, are used for controlling the amount of carbon required for the prevailing taste and odor conditions.

"Moisturized" carbon may be used where wet storage is not practical. The quality of this type of carbon is the same as that of the standard grades, the only difference being that approximately 20% water, based on the weight of the carbon, is added to minimize dusting.

NATURAL-RESOURCES SURVEY OF NEW ENGLAND AND NEW YORK

BY HARRY L. FOX*

[*Presented January 18, 1951.*]

Section 205 of Public Law 516, enacted by the 81st Congress and approved May 17, 1950, authorized and directed the Secretary of the Army to cause preliminary examinations and surveys for flood control and allied purposes to be made under the direction of the Chief of Engineers in drainage areas in the United States, and authorized and directed the Secretary of Agriculture to cause preliminary examinations and surveys for run-off and water flow retardation and soil erosion prevention on such drainage areas. The localities in which these examinations and surveys were directed by the Congress included the "Merrimack and Connecticut Rivers and their tributaries and such other streams in the States of Maine, New Hampshire, Vermont, Massachusetts, Connecticut and Rhode Island, where power development appears feasible and practicable, to determine the hydroelectric potentials, in combination with other water and resource development."

In approving this Act the President of the United States pointed out that the measure failed to provide for a comprehensive study of multiple-purpose resource development for the New England-New York area with appropriate participation by the Federal agencies and the states concerned. Consequently, on October 9, 1950, in identical letters to six Federal agencies, President Truman said in part:

> "I am sure you will agree with me that experience in natural resources development emphasizes the fact that plans for the most effective utilization of water resources must take into account all the multiple-purposes and benefits, and also the interrelationships between water and land resources. Moreover, studies of the potential development of these related resources should be based on proper geographical or regional areas . . . ."
>
> "In order to realize to the greatest extent possible under existing authority the benefits which would stem from this legislation and to provide essential

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coordination of the activities of the various Federal agencies in studying the resources potential of this area, I am requesting that the various Federal agencies concerned, organize a temporary inter-agency committee for the purpose of initiating a comprehensive survey of the resources of this region, and preparing recommendations for the development, utilization and conservation of those resources. In view of the general provisions of Section 205 of Public Law 516, I am designating the Department of the Army as the Chairman agency. The survey to be conducted by this inter-agency committee should include the six New England States and New York State."

On October 27, 1950, the Federal Inter-Agency River Basin Committee adopted the following resolution:

To carry out the instructions of the President in his letter dated October 9, 1950, providing for a comprehensive survey of the resources of the New England-New York region, and preparation of recommendations for the development, utilization and conservation of those resources, there is established a New England-New York Inter-Agency Committee. This Committee will be guided by the policies and purposes of the Federal Inter-Agency River Basin Committee established by the Federal Inter-Agency Agreement dated December 29, 1943, thus providing a means through which the field representatives of the participating Federal agencies may effectively interchange information and coordinate their activities among themselves and with those of the states, in the investigation and preparation of a report covering the water and land resources of the New England-New York region.

The Committee shall consist of one member each from the Department of the Army, Department of Interior, Department of Agriculture, Department of Commerce, Federal Power Commission, and Federal Security Agency. The member from the Department of the Army will be Chairman of the Committee.

In addition to the six Federal agencies mentioned above, the State Department will be represented in matters relating to Canada.

The survey will be a cooperative undertaking by the Federal and State Governments. The Governors of the seven states concerned have been invited to participate actively in Committee meetings. Each Governor has accepted and has appointed a representative to coordinate the work of the state departments with that of the Federal agencies. Colonel Frech, the Chairman of the Committee, has opened an office in Boston, where work will be coordinated to avoid duplication of effort.

The President in his letter of October 9th stated that—

"The comprehensive study of land and water resources of this area should include, among other matters, coverage of electric power generation and

transmission, forest management, fish and wildlife conservation, flood control, mineral development, municipal and industrial water supply, navigation, pollution control, recreation, and soil conservation. The necessary first step in such a study is an inventory of the land, water, and all of the related natural resources available for utilization, together with a survey of the projected regional and national requirements which might be met through more effective utilization of the natural resources of the region. When these basic facts on resources and needs have been collected and analyzed, the Committee should then proceed to determine what development and conservation projects are feasible and desirable, and to prepare recommendations for specific action to carry them out."

Necessary field work will be accomplished by the personnel and facilities of the agency offices normally operating in the survey area.

Sub-committees and Work Groups will be appointed for each of the studies to be made under appropriate subject headings. These groups will include both Federal and State members. In each of these groups the member representing the agency primarily concerned with the subject by legislative authorization will be the Chairman or Group Leader. Examples:—Water Supply—Federal Security Agency (Public Health Service); Fish & Wildlife—Department of Interior; Flood Control—Department of the Army.

The wealth of existing information available from Federal, State and local sources and in special reports will be sifted and pertinent data will be extracted and brought up to date. The Committee proposes to correlate its activities and interchange information freely with the Committee of New England and such other groups as may be studying matters relating to natural resources.

Following procedures which have been found most efficient and satisfactory by other regional inter-agency committees, three types of meetings are planned in the furtherance of the survey—technical meetings, regular meetings of the committee, and public hearings. Technical meetings are those at which technical discussions predominate. They will be attended by Committee members, their assistants, and such non-Federal representatives as may be concerned with the technical matters under discussion.

Regular meetings are those at which the Governors of the seven states, and/or their representatives, and the Committee Members meet with state and local officials. Although these meetings will be

open to the public, I believe it will be to our best interests to limit participation in the discussions to Federal and state representatives on the Committee and those whom they specifically invite to participate. The agenda for each meeting will be prepared in advance with concurrence of Federal and state participants. Discussions will be confined to the pre-arranged program.

At every step as the study progresses, the people of the seven-state area will be informed and consulted. Their experience, their knowledge and their viewpoints will be sought. This the Committee will do through public hearings to be held at points convenient to public access throughout the region. It will be done also through active participation of the State Executives at the regular meetings of the Committee and through conference and consultation with appropriate state and local groups. But it is through the public hearings that we can gain the closest contact with the people themselves, and learn their needs and their desires.

In the execution of this survey and the resultant recommendations, the agencies of the Federal Government are concerned solely with searching out natural potentials of the area and assisting the states and their people in determining sound solutions for problems involving future development.

It is through the cooperation and assistance of such organizations as you represent here today, the New England Water Works Association, that the mission can be most successfully accomplished.

TREATING ALGAE UNDER THE ICE AT WESTFIELD, MASSACHUSETTS

BY E. A. SNOW, JR., AND ANGELO IANTOSCA*

[*Read February 15, 1951.*]

During the latter part of February, 1950, the city of Westfield, Mass., began to experience trouble with algae under the ice in the Granville Reservoir, which has recently been officially named the Orin E. Parks Memorial Reservoir. The Granville supply has a watershed area of 6.4 sq mi. The storage reservoir, built in 1929, has an area at the flow line of 72 acres and a capacity of 630 mil gal. The dam is earthen with a concrete core wall. The greatest depth is approximately 67 ft. Since such deep reservoirs seldom have algae troubles when covered with thick ice, it may be of some interest to record how the problem was handled.

The water from the Granville Reservoir discharges into Winchell Reservoir, whence it passes through a 14-inch pipe into the Sackett distributing reservoir, the water being treated with chloramine at a point about 500 ft below the Winchell Reservoir. Sackett Reservoir has a capacity of 1.7 mil gal, with an elevation of 373 ft (M.S.L.). The water flows from this reservoir by gravity to the city, serving in general the southerly portion of the city.

Winchell Reservoir was built in 1898 and has a capacity of 3.1 mil gal. It has a masonry dam, gravel bottom, and a depth of 11½ ft. It is possible to bypass Winchell by means of a 20-inch pipeline, which connects Granville Reservoir to the 14-inch pipe-line below Winchell.

Complaints of a fishy taste in the drinking water were first received by the Westfield Water Department on February 27, 1950, after which Harry Angell, Deputy Superintendent in charge of the water department, notified the State Department of Public Health. On February 24, 1950, Granville Reservoir began to spill over into Winchell, three days before complaints were received. Evidently the

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algae had accumulated under the ice and were carried into Winchell Reservoir by the overflow. Prior to this, the water suppled to the city was taken at the 20-foot level in Granville, which is below the normal level at which these algae can live.

The authors made a trip to obtain samples on March 7, 1950. At this time a green growth could be seen just under clear ice at the spillway. A sample, taken at the spillway, contained 3,500 standard units of *Uroglenopsis* per cc, while another sample, taken at the boat landing, was quite clear and contained only a few *Dinobryon*.

Uroglenopsis is one of the colonial forms of algae classified, according to Whipple (1), in the Mastigophora (or literally whip-bearer) group under the Protozoa. A colony of *Uroglenopsis* has somewhat the appearance of a pin cushion under the microscope and yet is just visible to the naked eye.

Dinobryon is classified in the same family as *Uroglenopsis* and consists of a branching colony, each individual of which has a vase-shaped lorica (or shell), opening at each end, the narrow lower end being attached to the parent cell below it. The upper end is wider and the organism itself moves inside the lorica, although attached to one side. When warmed up, the cells pop out of this larger end and become detached, the round yellow-green cells soon decomposing, to give off the oils which are the source of the fishy odor.

Five samples were collected on March 10 at different points around the reservoir. These showed large numbers of *Uroglenopsis* at all points except at Tillotson Brook and in Sackett Reservoir. The odor of these samples correlated well with the numbers of algae, as shown in Table 1. According to Frank Hale (2), *Uroglena* causes an oily, fishy taste in water when present in 500-1,000 standard units per cc. In larger amounts the flavor is even worse, similar to cod-liver oil.

The fact that *Uroglenopsis* was present in amounts 100 to 300 times as large as the quantity of *Dinobryon* was enough to show that the main trouble was with the *Uroglenopsis*. Smaller numbers of *Glenodinium* and *Peridinium* were present and probably added to the general fishy character of the odor and taste.

John Spencer (3), in an excellent paper on the algae of Quabbin Reservoir, noted that *Dinobryon* was present in Quabbin waters from May through October, 1949, although *Uroglenopsis* was found only

TABLE 1.—WATER SAMPLES FROM WESTFIELD PUBLIC SUPPLIES
Water from Granville Reservoir, Westfield (Except #7)

Source of sample	Date col.	Cold odor	Hot odor	Dino-bryon	Peri-dinium	Uroglen-opsis	Copper (ppm)
1. At spillway	3/7	5Df	—	—	—	3,500	—
2. At boat landing	"	1E	—	16	—	—	—
3. Pete Oleson's Cove	3/10	—	5Df	2	—	600	—
4. Hendrickson's Cove	"	—	4Df	24	—	290	—
5. Tillotson's Brook	"	—	1 V	—	—	—	—
6. At spillway	"	—	2Df	—	—	1,000	—
7. Sackett Reservoir	"	—	1Df	0	0	0	—
8. Hendrickson's Cove	3/13	4Df	—	—	24	900	—
9. Hendrickson's cove, treated area	"	—	1E	44	72	10	—
10. Cove north of Tillotson's Brook	"	—	4Df	++	++	1,200	—
11. Oleson's Cove beyond treated area	"	—	1Df	++	++	—	—
12. At spillway	"	—	4Df	—	—	2,000	—
13. Sta. 1 Cove	3/20	—	1D	86	—	60	0.08
14. 50' from gatehouse #4	"	—	1Df	108	540	—	0.06
15. First Cove #5	"	—	2M	—	—	10	0.44
16. Second Cove #6	"	—	1Bg	—	—	0	0.90

++means that the organism was present in large amounts but not counted.

twice in August and September. During this sampling period he found only 4 genera of Chrysophyceae, including *Synura* and *Mallomonas*, and altogether they accounted for only 1.2% of the total net catch of plankton.

Lackey (4), in an article on "Plankton as Related to Nuisance Conditions in Surface Water", points out that reservoirs in areas underlain by granite rocks are often troubled by *Uroglenopsis*, *Synura* and similar forms. These types are common to waters which are slightly acid and are seldom found in hard waters, which are generally alkaline. The causes of algal blooms are not very well understood, but proper temperature conditions and an accumulation of nutrients are important. Sawyer (5) and others have shown that phosphates and nitrogen are limiting nutrients for some algae, whereas manganese has been shown to be necessary for blue-green algal blooms. Several authors have pointed this out and Reed (6) has shown how the manganese in Quabbin has become almost nil below 50 ft from the surface, since the reservoir was filled. There have been no major blooms of *Anabaena* or other blue-greens since the filling occurred.

Since the algae found in Granville Reservoir were organisms which require light for growth, it was considered probable that few, if any, of these plants would be found much below the surface. Hence an easy way out of the trouble was to draw from a lower level. Water was thereafter drawn from the 20-foot level, and a sample taken about 5 ft below the surface of the ice showed only one-half as many colonies of *Uroglenopsis* as at the surface. The results also proved our contention, since there were no more complaints from the consumers.

Other measures were deemed expedient, however, for several reasons. First, to eliminate the bad actors, copper sulfate is generally used. We considered using copper silicate, which it is claimed will dissolve only to the extent of about 1 ppm (7). This could be placed in burlap bags and suspended under the ice; but since no reference could be found for its practical use, and there was a possibility of killing fish and also promoting the growth of diatoms through increasing the soluble silica in the reservoir, it was considered safer to use the standard copper-sulfate treatment. The method actually used will be described later.

Another measure which could have been used is to run off some of the surface water at the spillway, to get rid of the concentrated growths just under the ice, which had been noticed there, especially where the ice was thinner and clear. However, in this case, the algal growths would have continued to spill over into the Winchell Reservoir.

In order to prevent the taste from accumulating in Winchell Reservoir, the gate on the 20-inch line at Granville Reservoir was opened farther, to prevent any overflow at the spillway by lowering the level of the water surface.

Since it was decided to use copper sulfate in any case, the problem now was the method of application of the algicide through 16 in. of ice. The area of the reservoir covers approximately 72 acres; therefore, a tremendous task would be involved, as it was necessary to chop holes at regular intervals in order to apply the copper sulfate.

Seven men, chopping all morning, covered only 1/10 of the area of the ice. This area, when samples had been examined, still showed up to 2,000 standard units of *Uroglenopsis* per cc and evidently the treatment was not effective.

Since this method was time-consuming and not effective as to

results produced, a new procedure was evolved, mostly through the ingenuity of the foreman of the water department, George Brew. It was found that holes, through which this solution could be applied, could be drilled in the ice by means of superheated steam, generated in a Hauck steam thawer—a piece of equipment generally on hand in most water departments and used in thawing out frozen hydrants.

On hand at the water department was a small, 1½-inch rotary pump, capable of pumping under 80-100 lbs pressure. This pump, installed on a small trailer, was powered by means of a small Star gasoline engine and was used by the water department for forest-fire fighting purposes on the watershed. The pump and steam generator were taken onto the surface of the ice and 1½-inch holes were made through the ice by means of superheated steam, at intervals of 30 ft over the surface. In making the holes through the ice, the average time required to make a single hole through 16 in. of ice was 38 seconds. A 6% solution of copper sulfate was made and pumped under the ice through a discharge pipe, terminating in an elbow, the open end of which contained a small orifice, in order to apply the material at a greater velocity for dispersal purposes.

The total labor involved in treating 20 acres of the reservoir was five days with six men and a foreman, and 1000 lbs of copper sulfate were consumed. The whole surface of the reservoir was not treated on the basis of the samples obtained, which indicated that the organisms were concentrated at various points that the 20 acres would more than adequately cover (see Fig. 1). During the process of applying the copper sulfate, the solution was constantly agitated by the operation of valves, which would return the solution to the tank when the algicide was not being actually applied to the water. By such means, any sedimentation in the solution tank was prevented and a reasonably uniform solution was being applied at all times. Water was pumped from the reservoir to make up the solution being applied. The application of the solution at each point was timed in order to prevent an overdose at any one point and to insure as uniform a distribution as possible.

For the sake of the record it may be noted that 16 holes were thawed and treated in 21 minutes. On an acreage basis, 21 minutes were required to treat approximately 1/5 of an acre.

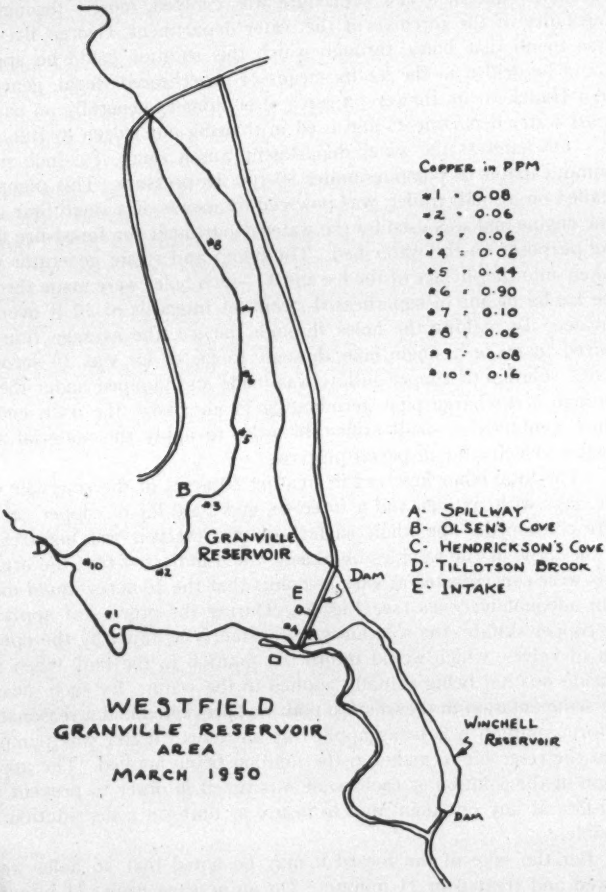
Copper in PPM
#1 - 0.08
#2 - 0.06
#3 - 0.06
#4 - 0.06
#5 - 0.44
#6 - 0.90
#7 - 0.10
#8 - 0.06
#9 - 0.08
#10 - 0.16
A- Spillway
B- Olsen's Cove
C- Hendrickson's Cove
D- Tillotson Brook
E- Intake
Granville Reservoir
Dam
WESTFIELD
GRANVILLE RESERVOIR
AREA
MARCH 1950
Winchell Reservoir
Dam

FIG. 1.

Subsequent to the treatment, samples were collected at the various stations as before and were analyzed in addition for copper. In most instances both the numbers of algae and the odor had been decreased significantly. In one case, with 0.9 ppm of copper, the odor was reduced so that it would not be noticeable to the average person and there were no signs of *Dinobryon* or *Uroglenopsis*. It might be of interest to note here that a sample, collected as rapidly as possible between stations 1 and 2, 5 ft away from a treated hole, contained 0.16 ppm of copper, showing that the spread of the copper must have been considerable by use of the special nozzle. However, at the spillway there were still considerable numbers of *Dinobryon* and *Peridinium*, but, since this was at the surface, it probably had no significance as far as the consumers were concerned. In spite of our fears of overdosage due to this injection method, no dead fish were found. The dosage applied to the reservoir was that recommended by Hale (2) for *Uroglenopsis*, a dosage of approximately 0.2 ppm. Of course, we should bear in mind that these organisms tended to collect at the surface under the ice, and the algicide was injected and dispersed at the surface and allowed to settle through the algal bloom. This procedure evidently is the reason for the good results obtained and may also explain the absence of dead fish.

From the above data and other experiences, we believe it may be reasonable to make the following conclusions:

1. Undoubtedly the "fishy" taste and odor in the water was due to the presence of large numbers of *Uroglenopsis* and *Dinobryon*. The taste was also fortified by *Glenodinium*, *Peridinium* and other algae present in several locations.
2. Drawing from a lower level was the quickest method of circumventing the nuisance and preventing the algal bloom from reaching the intake reservoir. This method was very effective.
3. As usual in such cases, copper sulfate was needed really to eradicate the algae.
4. An improved method of making holes through the ice was devised. All credit for this should go to George Brew, foreman, and his willing crew.
5. The final tentative conclusion is that the reason for the unusual growth of algae in this deep reservoir was the drought of the summer of 1949. This dry spell caused a lowering of

the Granville Reservoir, so that about 20 ft of shoreline were exposed, for the first time since construction, to the sun and air, and green plants grew thereon. When the reservoir again filled, these areas were flooded and the plant material was dissolved, providing food for bacteria, algae, etc.

The authors have been told that other communities in New England experienced similar difficulties.

Acknowledgments

The authors wish to acknowledge the splendid coöperation of all those involved in this problem of algae treatment.

We wish to thank Francis Martin, Superintendent of Public Works, Harry Angell, Deputy Superintendent of the Water Department, George Brew, Foreman, and other members of the Water Department of Westfield, Mass.

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THE CIVIL DEFENSE OF NEW ENGLAND

BY ALBERT D. O'CONNOR*

[*Read March 15, 1951.*]

I sincerely appreciate the honor you have paid me by inviting me here today. But even more I appreciate and welcome the evidence which this meeting gives me of your alertness to the danger that threatens us all today.

The general public is not yet fully alert to this danger. Many people doubt that there is any danger. Or if they do think there is danger, they prefer not to think about it. They hope it will go away. It won't.

The danger is grimly real. For the first time since the Indian wars we have an enemy that can attack us in our homes. Millions of men, women and children in this country today run the same risk of death as our armed forces. This is especially true of the critical Northeastern area, where there is such a heavy concentration of primary targets for enemy bombers. In New England alone more than five million people live in these target cities.

The reason why an enemy would attack our centers of population and production are only too obvious. The outcome of both World War I and World War II was decided by the weight of American industrial production in support of a determined fighting force. Our enemy knows this as well as we do. One of the first things he will do is attempt to destroy our production capacity and carry direct attack against our civilian communities, in order to disrupt our support of the war effort.

We must never forget for an instant that the Russians are able right now—today—to drop atomic bombs on a dozen or more of our major cities. There is nothing we can do to stop them. It has been reported by the Air Force that at least 70% of the enemy bombers would get through our military defenses. Their attack could come—

*Northeastern States Regional Director, Federal Civil Defense Administration, 143 Speen St., Natick, Mass.

the Granville Reservoir, so that about 20 ft of shoreline were exposed, for the first time since construction, to the sun and air, and green plants grew thereon. When the reservoir again filled, these areas were flooded and the plant material was dissolved, providing food for bacteria, algae, etc.

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The danger is grimly real. For the first time since the Indian wars we have an enemy that can attack us in our homes. Millions of men, women and children in this country today run the same risk of death as our armed forces. This is especially true of the critical Northeastern area, where there is such a heavy concentration of primary targets for enemy bombers. In New England alone more than five million people live in these target cities.

The reason why an enemy would attack our centers of population and production are only too obvious. The outcome of both World War I and World War II was decided by the weight of American industrial production in support of a determined fighting force. Our enemy knows this as well as we do. One of the first things he will do is attempt to destroy our production capacity and carry direct attack against our civilian communities, in order to disrupt our support of the war effort.

We must never forget for an instant that the Russians are able right now—today—to drop atomic bombs on a dozen or more of our major cities. There is nothing we can do to stop them. It has been reported by the Air Force that at least 70% of the enemy bombers would get through our military defenses. Their attack could come—

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as things now stand—with little or no warning. And the civilian casualties resulting from a surprise attack could be many times greater than our military forces have suffered thus far in any or all of our wars.

What if the enemy should come today—before we have our civil defense program in full working order? That is the thought in the mind of every civil defense official in the country. With the public fully informed of what it has to do to defend and protect itself and the communities of the nation, we could save more than half of the lives that would otherwise be lost, and we could quickly restore our production of war materials after an attack. Without a fully informed and fully prepared public, on the other hand, we might be so hard hit that we could not recover. We might face defeat and the loss of the freedom which we have enjoyed for so many generations.

Now what have we done to date in order to save our lives and liberty? Let me give you a quick resumé. From 1945 to 1949, the responsibility for civil defense rested with the military. The military made studies, conducted much research, and submitted a report—the famous Hopley Report—which recognized that civil defense is properly the responsibility of civil government. Accordingly the President, in March, 1949, assigned civil defense to the National Security Resources Board for planning purposes. In September of last year the NSRB submitted a report of *its* findings, research and recommendations; and on December 1, by Executive Order, the President established the present Federal Civil Defense Administration. On January 12 of this year Congress passed the Federal Civil Defense Act under which this agency now operates.

In the meantime, however, the States went right ahead with their own planning and organizing, without waiting for the Federal Government. Every state has a full-time paid director of civil defense and each is making such progress in effecting a civil defense organization at the state and city levels. The New England states, I am happy to report, have made much progress in that regard. The training of volunteers is now in progress at the state and city levels.

Every citizen has a part to play in civil defense. But the part to be played by workers in their auxiliaries in the health and engineer-

ing services will be of vital importance, especially as these services relate to water supply and to sanitation.

The importance of restoring and maintaining water supplies following a disaster cannot be overemphasized. Reports of the Hiroshima and Nagasaki bombings note that the public water supplies were rendered almost totally inoperable. Not only were the distribution systems unable to deliver the quantities of water needed for fire fighting and other purposes, but they were also subjected to gross pollution from sewage and other contaminating materials.

It does not take much imagination, even for a layman, to visualize the damage that would be done to the water system of a city like Boston, for example, by two atom bomb bursts—one overhead and the other underwater in the port. Water standpipes within the heavy-damage radii of both bombs would be destroyed or damaged beyond use. Pumping stations would be washed out by the underwater burst, contaminated by radioactivity, or damaged by flash-fire. Reservoirs downwind from the underwater burst would be contaminated. Water mains, hydrants and main supply tunnels would be broken. And thousands of tons of debris would fill the streets and highways, blocking access to the damaged areas.

And I must point out that this kind of destruction might very well fall upon a much smaller city than Boston. It might even descend upon a community in Maine, New Hampshire, or Vermont. If an enemy pilot found that he could not reach his primary or his secondary target, he would drop his bomb on the nearest community, in order to lighten his aircraft and return to his base. Remember that some 30% of the attacking bombers would not get through our military defenses. They would be intercepted in many cases over Maine, New Hampshire and Vermont; and some of them would drop their bombs there, I feel sure. No community is safe. No one is immune from the effects of an atomic attack.

If you have not already read our basic book on civil defense, may I urge you to do so? The title is "United States Civil Defense" and it can be purchased for 25 cents from the Superintendent of Documents, Government Printing Office, Washington. Part III of this book should be of particular interest to you, because it translates civil defense policy and concepts into operation. It answers those State and

city officials who are asking, "How do we start?" and serves as a check list to those whose programs are already started.

Let me recommend to you, also, our later book on "Health Services and Special Weapons Defense." This book costs 60 cents and can be obtained from the same source as the other one. Chapter 8 on "Water" you certainly should read, if you have not already done so. Chapter 9, on "Sanitation Service," is another chapter that concerns you very much, since in a bomb disaster your water system and your sewerage system will inevitably react upon each other.

I have been asked to tell you just where our office—the first regional office of the Federal Civil Defense Administration—fits into the picture here in New England. Let me start out by quoting the declaration of policy which appears at the very beginning of the Federal Civil Defense Act. It is the policy and intent of Congress, according to this declaration, that the responsibility for civil defense shall be vested primarily in the several States and their political subdivisions. The Federal Government shall provide necessary coördination and guidance, shall be responsible for the operation of the Federal Civil Defense Administration, and shall provide necessary assistance to the States.

The Federal Government cannot, and should not, operate the State and local civil defense programs with Federal employees. The States have inherent powers and accompanying responsibility. They are clearly qualified to coördinate civil defense operations within their boundaries and, in emergency, to direct them. In the same way, the cities, counties and towns are best qualified to handle their own operating functions.

The responsibility of the Federal Government is to establish a national civil defense plan with accompanying policy, and to issue informational and educational material about both the plan and the policy. The Federal Government will provide courses and facilities for schooling and training. It will coördinate interstate operations. It will furnish some of the essential equipment, and will advise the States concerning the establishment of stockpiles of medical and other supplies, needed in time of disaster. And in all matters of civil defense, I should add, the Federal Government deals directly with the

State—that is, with the Governor of the State or with his duly delegated State Civil Defense Director.

Our office is a part of the Federal Government which has been, as you might say, projected into the heart of New England, in order to serve New England more quickly and better. It is an immediate and authoritative contact between Washington and your State capitols. This office speaks for the Federal Government in this region—and please note that when it speaks, it does *not* order, direct, or tell any State or local government what it should do. It advises and recommends; it guides and assists; it plans and coördinates. In one word, it serves the New England States in all matters pertaining to civil defense.

In order to serve you gentlemen in particular, we shall have very soon on our regional staff a deputy in charge of health services; and a little later we expect to have another deputy in charge of engineering. These men will deal directly with their counterparts in your State civil defense offices and I am confident that through this close Federal and State relationship, we shall be able to help you solve your civil defense problems in short order.

Through this relationship, therefore, I promise you my complete coöperation, and I know that I can expect the same from you. I assure you that wholehearted coöperation by all hands is absolutely essential to the success of the civil defense program. Preparedness will go a long way in minimizing effects of atomic bombs. With coöperation, plus hard thinking and considerably more get-up-and-go, we have a chance to be prepared for the enemy before he strikes us.

Now the members of the panel will tell you more specifically than I can tell you about what you need to do. But I should like to give you a quick summary of what the Hopley Report says on this subject.

Your protective and remedial measures will include policing of the vicinity of the intake and other vital works, as well as restriction of the use of the watershed by unauthorized persons. Also special analyses to detect poisons and unexpected pollution. Also designation of experienced crews and equipment, ready to make extensive repairs to the system. Also, of course, plans for the provision of an alternate source of supply.

There are major parts of a water-supply system that are particularly vulnerable, such as aqueducts, pumping stations, treatment plants and storage tanks. Damage to one or more of these units would result in partial or total failure of service. Advance planning—and I repeat, *advance* planning—must contemplate measures for safeguarding these units in so far as practicable.

Where a system has only one pumping station or one source of power, you must give consideration to the matter of providing standby pumping equipment and auxiliary sources of power.

Mains leading to ground reservoirs and elevated storage tanks should be so valved that they can be shut off immediately in case the reservoir or tank is damaged or destroyed. This will conserve the water for fire-fighting purposes. Speed in valving off the damaged mains and effecting repairs is essential. Therefore, you should prepare a complete map of the water-distribution system, showing such information as the exact location and size of each water main, valve, fire hydrant, cross-connection, pump and storage reservoir. Copies of this map should be kept at various locations for convenience and safety.

And here are a few more things you must do: (1) Make a survey of all available chlorine and chlorine compounds within your area. (2) Maintain an adequate supply of repair parts. (3) Make a survey of all private, institutional and industrial water systems in your area, including swimming pools, both private and commercial, which could be used in an emergency. (4) Make a survey of all water and milk tank trucks, with their drivers, for possible use in transporting water. (5) Provide an alternate means of communication between the waterworks pumping plant and the civil defense control center.

From this quick summary you can see that you have your work cut out for you. Just as we all have, if we are to survive.

NEW BILLING PRACTICE AT MANCHESTER

BY JAMES A. SWEENEY*

[*Read May 17, 1951.*]

Manchester recently changed over from a single-zone, quarterly, billing and collecting system to a three-zone, quarterly rotating system, that brings up one zone for billing and collecting each month.

The new system was conversational three years ago. Under the quarterly billing, approximately 25% of our total annual revenue was collected in 20 days every three months. The bills were for water that in some cases was used three months before. We felt that a system which would bring the money in more uniformly and our billing up to date would prove an advantage. The number of customers was also increasing to the extent that it was crowding a bookkeeping system which had been instituted years ago. This is apparent now as we look back, although previous to actually putting the new system into operation, the office force was quite well satisfied with the single-zone quarterly arrangement.

Three or more years ago another problem was becoming apparent: we were trying to operate a modern, growing organization in space originally provided in 1872. We were in need of more room for our office force and our equipment. We were in need of better meter-repair facilities and also in need of some additional help to care for the increasing number of customers, and this, in turn, required more office space. Equipment that should be under cover was being stored outside. All this materialized into the present building we are in today. A detailed study of where to erect such a building brought us to this location. Here we have a complete centralization of administration, office, garage, equipment, and main and service-materials storage, which enhances our efficiency in the discharge of daily work and in emergencies.

Moving over here, however, removed a central collection point, that the public had found best suited to its needs. That was easily

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taken care of by employing the same practice that the local telephone company uses—convenient collection spots in the downtown business section of the city, together with the addition of a collection agent on the West side of the Merrimack River, which divides the city geographically. We approached potential collectors and found they were willing to do the work if it could be done with their regular complement of help. Quarterly collections would require additional help. Well, we had talked about monthly billing—now we needed it. Therefore we set about working it out.

Procedure

It was estimated that about a month would be required to make the change-over. There was considerable preliminary work to be done before the change. First, the city had to be divided fairly evenly into three zones. Before the end of the third quarter we simply made a count of meters in what appeared to be natural zones, made some adjustment, and arrived at what appears on our zone map.

We have approximately 4,800 meters in Zone 1; 4,900 in Zone 2, and 5,300 in Zone 3. Then we re-arranged our addressograph plates into zones. This was perhaps the major job. Our head meter-reader, who keeps the addressograph plates up to date, spent two weeks at the re-arranging job. Next, we had to provide new ledger cards for the zones. We decided to have an identifying color for each zone and the same identifying color for the bills for each zone.

Change-over Work

After the ledger cards were arranged in the proper zone, Mr. Graves of Bank Service, Inc., of Boston, moved in with equipment and girls, to transfer the following data from the cards in use to the new cards: the name and address, service number, meter size, kind and number. Six girls required 2½ weeks to transfer 15,000 cards, at a cost of $490.00. The meter readings were entered by our own office force directly from the meter readers' books as they worked along on the billing.

One of the objectives of inaugurating this new system was a continuous flow of funds into the Department. This required a change in the bookkeeping set-up. Mr. Riccio, a certified public accountant, of Manchester, was hired to set up the books to provide records for

the monthly collection system. To make monthly collections and to close the books monthly we only required the addition of a Daily Sales Summary sheet and a Daily Cash Summary sheet.

No changes were required in the meter readers' books.

Notifying the Public

The public had to be informed of the proposed change. The plan was publicized by inserting a story in the local paper. Then, as the bills in each zone came due, the public was again notified by the press. As each zone became due a second time, the same form of notification was used again. This was sufficient to reach a large majority of our customers.

Results of Present System

The Public

The public has accepted the new plan and, for the most part, finds it very convenient to use the various payment centers. Changing over meant that the people in Zone 3 practically paid two quarters in one, which brought a few comments, and the people in Zone 2 had five months' to pay, which also required some explaining. Actually, however, it was a very easy transition.

Property owners who own a number of pieces of real estate used to get all their bills at one time; now they get them by zones. This requires multiple payment trips and this has caused some comment.

Meter-reading Work

The meter readers now all work in one zone at a time, in place of regular routes. Twelve working days are required to make a complete reading. Then two days are spent on skips. The men find that they must go in the evening as close to supper time as possible and on Saturday mornings, in order to find people at home. This concentration of skips is beneficial to the office. Holidays and checking take up two days. The final working days are used to pass out the bills that the office force has ready.

An interesting note on skips is that the building boom on individual houses has required both husband and wife to work in order to swing it, and this means more skips for the men.

Meter-maintenance Truck Work

With all the meter readers working in one zone, we find that the truck work is zoned also. All "leaks" and "stops" are concentrated, which makes for efficiency.

Office Work

Whereas, under the single-zone system, the billing would proceed for six weeks and then the posting operation would be carried on for six weeks, the office now bills and posts simultaneously. The work is carried on at a more even pace, but actually there are more deadlines to meet. A typical month is as follows:

> The meter readers turn in their first day of readings. The billing begins. The posting is already in operation for the last zone. By the 22nd of the month the reading for Zone 1 is over and so is the billing. Posting is continuing for the preceding month. The job of arranging the bills for the multiple owners and getting the mailing list ready (owners who live in zones other than the one that is being billed are sent bills by mail) is completed in the next two days. The bills are then distributed by the meter readers during the last four working days. Collecting and posting has continued all the while. Non-payment notices for Zone 3 had to be mailed out after the 15th of the first month; collection of unpaid bills from Zone 2 had to be started the 10th of this month.

The above picture indicates the need for more careful timing than with the former system, but, interestingly enough, it is much smoother in operation.

The following is a resumé of the results on the office force:

1. Smoother operation.
2. Closer timing.
3. More mailing.
4. More collecting of unpaid bills.
5. Closing the books monthly in place of quarterly.
6. The addition of one posting machine.

Revenue Available

The former, single-zone quarterly method of billing and collecting brought in our revenue four times in the year. This income was for water that had been delivered as much as two months before the billing date. It should be borne in mind that the totaling of sales and amount of consumption was delayed two months also. Our expenses,

however, were current. In the warm months our expenses were high, but our peak revenue did not occur until fall or early winter.

Under this new system, the reading and billing are in the same month and the substantial part of our revenue is in by the 15th of the following month, just when our expenses come due. A financial statement each month shows us exactly where we stand. It is a much-improved way of doing business.

We should point out that our larger industrial accounts have been billed monthly for some time and were not affected by this change we have discussed.

Summary

To summarize: the introduction of our three-zone rotating system of billing and collecting has required some additional work and expense. However, the advantages of:

1. Better facilities of payment for the public;
2. Current financial and consumption statements;
3. Income current with our expenses;
4. Concentration of meter-maintenance truck work

more than offset the additional work and expense.

FUNDAMENTALS OF WATER FLUORIDATION

BY HARRY A. FABER*

[*Read September 10, 1951.*]

Each generation is inclined to believe that its problems are totally different from those of preceding generations. Actually, there are very few strictly new and novel problems—rather the old ones are magnified many times, as scientific knowledge becomes more complex.

This characteristic is well illustrated by the growing practice of water fluoridation. It is only fifty years ago that the condition of teeth now termed endemic fluorosis, or mottled enamel, was described. It is only twenty years ago that the existence of the fluoride ion in water was discovered and that it was identified as the causative agent of mottled enamel. This scientific knowledge presented no new problems, but it did complicate and magnify an old one.

Man's quest for pure water has always involved principles of practice and of philosophy. While these principles apply to each new development in water treatment, they have never before required the careful consideration necessitated in the adoption of water fluoridation.

Honest evaluation of fundamental knowledge is generally the best basis for deciding on a line of action; but there is frequently a wide difference in the individual interpretation of facts and, further, the facts considered are always a matter of selection. In this discussion, five fundamental facts of particular significance in the practice of water fluoridation have been selected, and emphasis is placed on what appears to be the general interpretation of their significance.

Fact 1—Fluorides Are a Natural Constituent of Water

The presence of fluorides in natural waters is associated with igneous rocks and with prior volcanic action, or with sedimentary rocks which have been influenced by the weathering of igneous rocks. Fluorides are, therefore, most likely to be present in ground waters

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mineralized by sandstone and limestone formations. As the fluorides in rocks are largely insoluble, the concentration of soluble fluorides present in natural waters almost never exceeds 15.0 ppm and is usually less than 1.0 ppm.

A study of the distribution of fluoride-bearing waters by Hill, Jelinek and Blayney (1) discloses that natural waters in the 32 states investigated usually contained low concentrations of fluorides, but that many natural waters—mostly located in Ohio, Indiana, Illinois, South Dakota and Texas—contained concentrations of fluoride ion greater than 1.0 ppm. The survey discloses that approximately 3,000,000 people are served by water supplies containing from 1.0 ppm fluoride ion to more than 5.0 ppm, as shown in Table 1.

TABLE 1.—POPULATION IN 32 STATES SERVED BY PUBLIC WATER SUPPLIES NATURALLY CONTAINING MORE THAN 1.0 PPM FLUORIDE ION

Approx. population served	Fluoride-ion content (ppm)
1,000,000	1.0-1.5
900,000	1.6-2.0
600,000	2.1-3.0
100,000	3.1-5.0
40,000	5.1 or higher

Near the beginning of this century, the condition of teeth now termed mottled enamel was noted and described. This defect is most pronounced in the permanent teeth and is produced during the period of tooth formation, largely during the first eight years. In mild cases, the enamel has a dull, chalky-white appearance, in contrast to the smooth and translucent character of normal enamel. In more severe cases, the defective enamel becomes pigmented and irregular splotches or bands develop on the surface; these range in color from yellow and light brown to black. In severe cases, the enamel surface appears corroded (2).

The relation between dental fluorosis and the concentration of fluoride ion in four public water supplies is illustrated in Fig. 1 and percentage distribution is shown graphically in Fig. 2.

Fluorides in Public Water Supplies
RELATED DENTAL FLUOROSIS EFFECTS

(DATA FROM H.T. DEAN)

AGE — CHILDREN EXAMINED — NO.

9-12 LUBBOCK, TEXAS
12-14 COLORADO SPRINGS, COLO.
12-14 AURORA, ILLINOIS
12-14 WAUKEGAN, ILLINOIS

		423	633	404	189
FLUORIDE (F) ION CONC. PPM.		0.0	1.2	2.6	4.4
SIGNS ABSENT	NORMAL	97.9	53.2	6.4	1.1
	QUESTIONABLE	1.9	31.8	19.8	1.1
WHITE OPAQE SPOTS	VERY MILD	0.2	13.9	42.1	12.2
	MILD	0.0	1.1	21.3	21.7
BROWN STAINS AND PITTING	MODERATE	0.0	0.0	8.9	46.0
	SEVERE	0.0	0.0	1.5	17.9

FIG. 1.

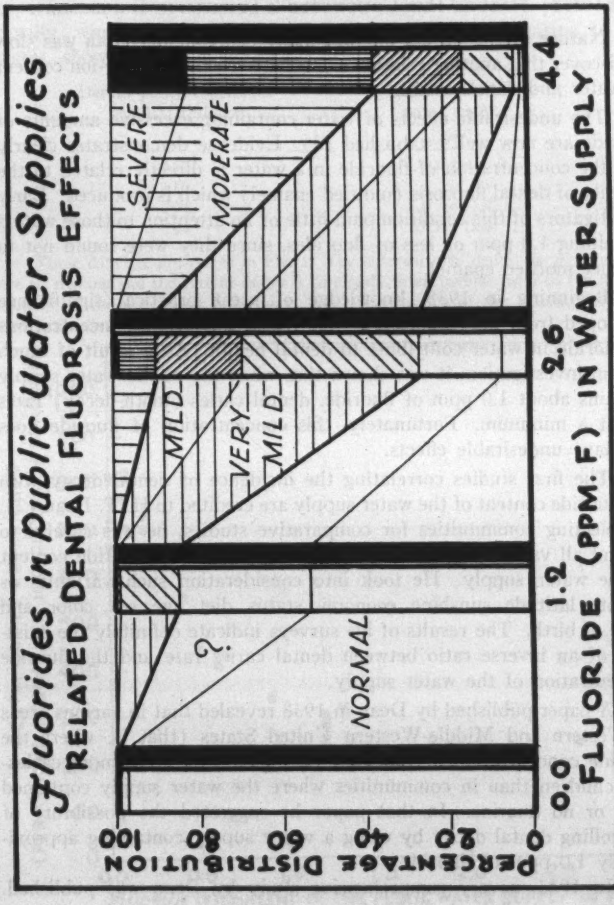
Fluorides in Public Water Supplies
RELATED DENTAL FLUOROSIS EFFECTS
PERCENTAGE DISTRIBUTION
0
20
40
60
80
100
SEVERE
MODERATE
MILD
VERY MILD
NORMAL
?
0.0
1.2
2.6
4.4
FLUORIDE (PPM. F) IN WATER SUPPLY

FIG. 2.

Fact 2—Nature Has Conducted a Scientific Experiment

Nature carries on not one but many experiments. Man was slow to discover that another relation exists between the fluoride-ion content of water and dental health.

The undesirable effects of water containing excessive amounts of fluoride are now well established (3). Evidence demonstrates clearly that the concentration of fluoride in a water is directly related to the severity of dental fluorosis (mottled enamel) which is produced. Early investigators of this condition paid little or no attention to those waters containing 1.0 ppm or less of fluorides, since they were found not to produce mottled enamel.

Beginning in 1938, knowledge of great practical significance developed from new studies. It was found that small concentrations of fluoride in water contribute to dental health. As a result of much careful investigation, it was shown that when the public water supply contains about 1.0 ppm of fluoride, dental caries (tooth-decay) rates are at a minimum. Fortunately, this concentration of fluoride does not have undesirable effects.

The first studies correlating the incidence of dental decay with the fluoride content of the water supply are credited to H. T. Dean (2). In selecting communities for comparative studies, he was careful to control all variable factors with the exception of the fluoride content of the water supply. He took into consideration such variables as climate, latitude, sunshine, economic status, diet, age, sex, color, and place of birth. The results of his surveys indicate definitely the existence of an inverse ratio between dental caries rate and the fluoride concentration of the water supply.

A paper published by Dean in 1938 revealed that in various areas of Western and Middle-Western United States (that is, where the fluoride concentration of the water is high) there were more caries-free children than in communities where the water supply contained little or no fluorine. In that paper he suggested the possibility of controlling dental decay by using a water supply containing approximately 1.0 ppm of fluoride.

In 1943, a very comprehensive study by Dean was published. This summarized the findings of an extensive study of the dental decay

experience of more than 7,000 children, aged 12 to 14 years. The results, when correlated with the concentration of fluorine in the water, show the following:

Dental decay experience per 100 children	Fluorides in the water supply (ppm)
740	Less than 0.5
416	0.5 to 0.9
294	1.0 to 1.4
244	More than 1.4

These data are illustrated in Fig. 3. The differences in dental decay experience are so striking and the rate of decay is so clearly in an inverse ratio to the fluoride content of the water that it seems evident the presence of this constituent is the preventive factor.

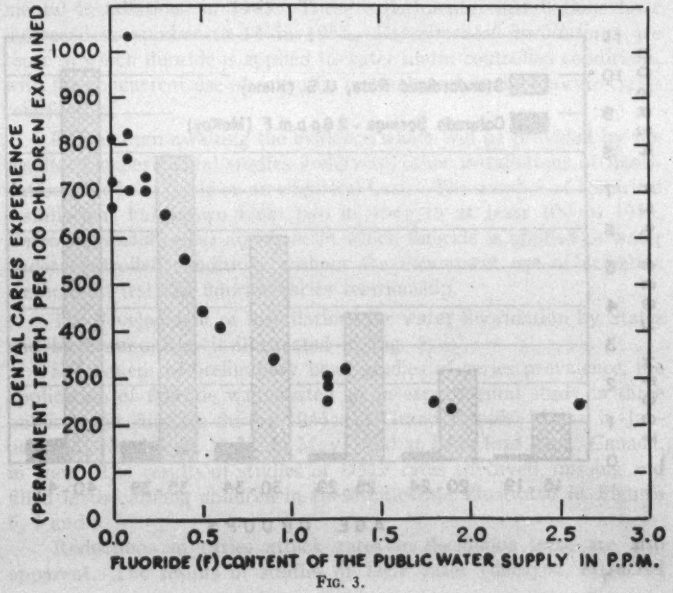

FIG. 3.

Evidence of the relation between dental caries and fluoride content of water supplies has been largely based upon studies of children. There have been few data concerning the dental health of adults who were exposed to fluoride-containing water during childhood. The results of a study by McKay provide some evidence that the inhibitory effect of fluoride, once acquired, may be permanent. His study was based on the examination of 400 adults who were natives of Colorado Springs, Colo., where the water supply has been a natural fluoride content of 2.6 ppm and has been in use for about 70 years. While these adults were found to have mild dental fluorosis, they exhibited an unusually low rate of permanent tooth loss. A comparison of the findings with the normal expectancy of tooth loss for the United States is illustrated in Fig. 4.

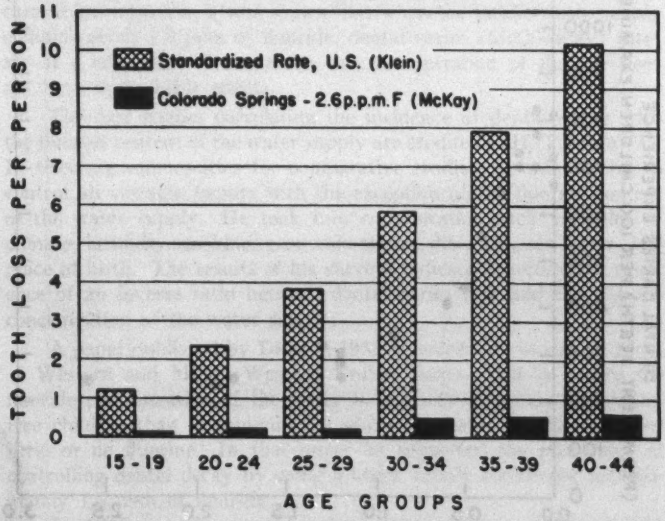

FIG. 4.

Fact 3—Fluoridation is Man's Imitation of Nature

The control of caries by adding fluoride to a public water supply is based on the hypothesis that the water so treated will have the same effect as one naturally containing fluoride. This hypothesis appears justified by chemical and biological considerations, by laboratory research, and by epidemiological evidence.

At least eight years will be required before a preliminary indication of the full effect of fluoridated water on dental caries can be determined; that is, until children have used fluoridated water throughout the period of tooth-enamel formation (through age eight for all teeth except the third permanent molars).

The fluoridation of water represents a significant large-scale study in public health. It was inaugurated with the operation of four experimental installations in 1945. These experimental installations have increased in number to 14 in 1951. *Experimental installations* are those in which fluoride is applied to water under controlled conditions, with the concurrent use of scientific methods to test the fluoride-caries relationship.

Rather than awaiting the evidence which will be provided by the results of experimental studies underway, other installations of fluoridation have been made on an empirical basis. The number of empirical installations has grown from two in 1946 to at least 100 in 1951. *Empirical installations* are those in which fluoride is applied to water under controlled conditions without the concurrent use of scientific methods to test the fluoride-caries relationship.

The development of installations for water fluoridation by States and by communities is illustrated in Fig. 5.

Subsequent to preliminary basic studies of caries prevalence, the application of fluoride was started as an experimental study in three public water supplies during 1945: at Grand Rapids, Mich., in January; at Newburgh, N. Y., in May; and at Brantford, Ont., Canada, in June. The results of studies of DMF rates (decayed, missing and filled teeth) among children in these cities are illustrated in Figures 6, 7 and 8.

Reductions in caries attack rates in deciduous teeth are also apparent. The results of studies of DEF rates (decayed, extracted

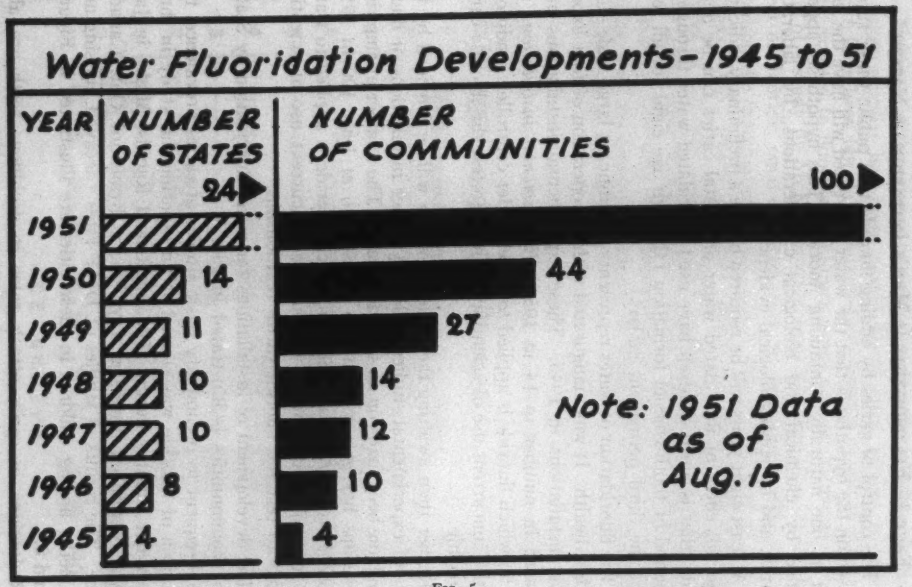
Water Fluoridation Developments - 1945 to 51
YEAR
NUMBER OF STATES
NUMBER OF COMMUNITIES
24
100
1951
1950
14
44
1949
11
27
1948
10
14
1947
10
12
1946
8
10
1945
4
4
Note: 1951 Data as of Aug. 15

FIG. 5.

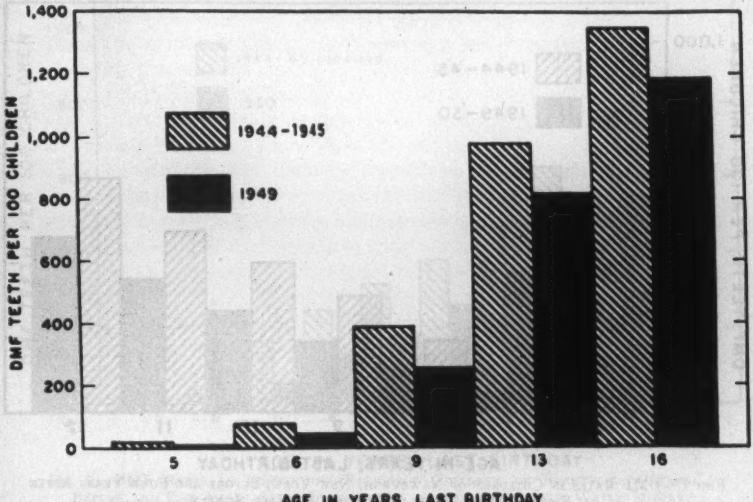

FIG. 6.—DMF RATES IN CONTINUOUS-RESIDENCE CHILDREN OF SELECTED AGES AT GRAND RAPIDS, MICHIGAN, BEFORE AND FOUR YEARS AFTER FLUORIDATION OF THE COMMUNITY WATER SUPPLY. (from: Dean, Arnold, Jay and Knutson, Pub. Health Rep., Oct. 27, 1950.)

and filled teeth) among five-year-old children in three cities and among kindergarten children in one city are illustrated in Fig. 9.

The results of these independent studies show a uniform and consistent reduction of dental caries and are highly indicative that artificially fluoridated domestic waters exert the same caries-inhibiting effects as do waters which carry the same concntrations of fluorine as a "natural" component (2).

FACT 4—NEW PROBLEMS OF OPERATION ARE INVOLVED IN FLUORIDATION

The water-works operator has found the installation and operation of equipment required in the practice of fluoridation to be relatively simple. The new, or different, problems presented by this treatment may be summarized:

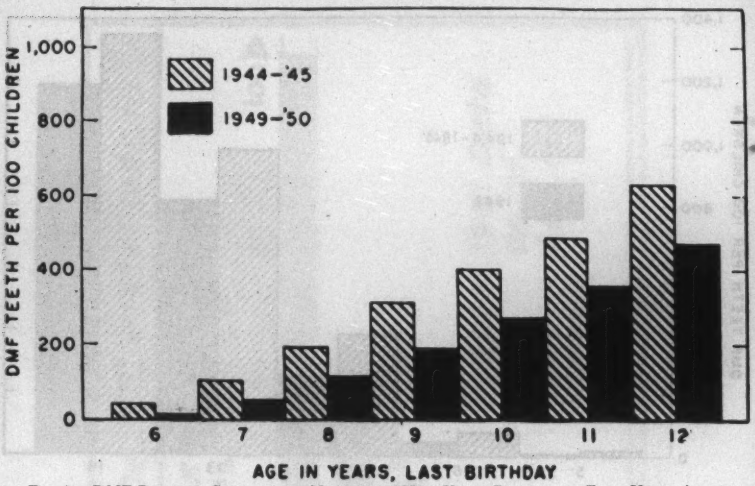

FIG. 7.—DMF RATES IN CHILDREN OF NEWBURGH, NEW YORK, BEFORE AND FOUR YEARS AFTER FLUORIDATION OF THE COMMUNITY WATER SUPPLY.
(from: Ast, Finn, and Chase, J. A. D. A., Feb., 1951.)

1. The chemical-feeding devices employed must operate with a degree of accuracy somewhat higher than that of conventional equipment.

2. The new chemical materials are toxic and must be handled with exceptional precautions.

3. The determination of residual fluoride in treated water constitutes a new and essential technique.

Devices for feeding fluorides accurately have generally been adapted from those machines originally designed for accurately applying chemicals in water treatment and in industrial processes. An adequate range and variety of fluoride feeders has been developed by equipment manufacturers.

A comprehensive review of fluoride chemical-feeding equipment and practical problems involved (4) is recommended reading. The new chemical materials and the determination of residual fluoride ion have been reviewed by other authors (5, 6).

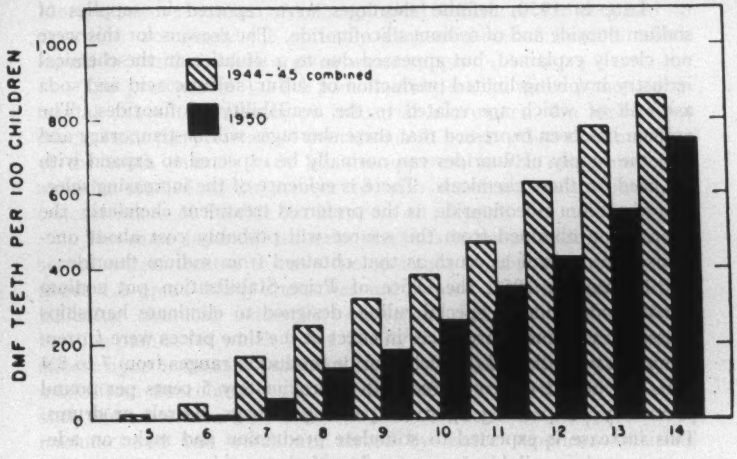

FIG. 8.—DMF RATES IN CONTINUOUS-RESIDENCE CHILDREN OF BRANTFORD, ONTARIO, BEFORE AND FIVE YEARS AFTER FLUORIDATION OF THE COMMUNITY WATER SUPPLY. (from: Hutton, Linscott and Williams, in Press.)

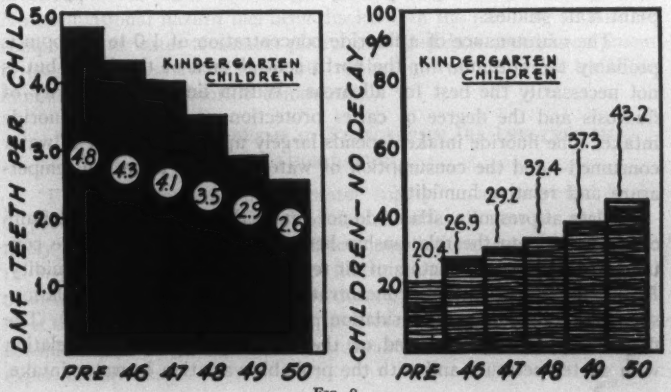

FIG. 9.

Late in 1950, definite shortages were reported in supplies of sodium fluoride and of sodium silicofluoride. The reasons for this were not clearly explained, but appeared due to a situation in the chemical industry involving limited production of sulfur, sulfuric acid and soda ash—all of which are related to the availability of fluorides. The opinion has been expressed that these shortages will be temporary and that the supply of fluorides can normally be expected to expand with the need for these chemicals. There is evidence of the increasing selection of sodium silicofluoride as the preferred treatment chemical; the fluoride ion obtained from this source will probably cost about one-quarter to one-half as much as that obtained from sodium fluoride.

In August, 1951, the Office of Price Stabilization put sodium silicofluoride under a special ruling, designed to eliminate hardships caused by extremely low prices in effect at the time prices were frozen. The price now allowed to silicofluoride producers ranges from 7 to 8.4 cents per pound (as compared with approximately 5 cents per pound previously), depending upon the packing in bags, barrels or drums. This increase is expected to stimulate production and make an adequate supply available for water-fluoridation needs.

A new product, termed "Flural", a mixture of alum and fluoride, is designed to serve both as a coagulant and fluoridating agent. It is now reported to be in pilot-plant production and has been applied in plant-scale studies.

The maintenance of a fluoride concentration of 1.0 to 1.2 ppm is probably the optimum for the north central area of the U. S., but is not necessarily the best for all areas. Within limits, the severity of fluorosis and the degree of caries protection vary with the fluoride intake. The fluoride intake depends largely upon the amount of water consumed—and the consumption of water depends upon the temperature and relative humidity.

Data at present available do not enable the formulation of definite conclusions as to the relationship between the optimum fluoride content of water and the factors of air temperature and relative humidity. Regulation of the fluoride concentration to approximate this relationship is practiced in the fluoridation program in Charlotte, N. C. The fluoride application is varied on the basis of a monthly correlation with air temperature and with the probable variation in water intake.

More extensive studies of climatological influences are required to determine accurately the optimum concentration of fluoride which should be maintained in a given water supply.

The presence of 1.0-1.2 ppm fluoride ion in water is not detrimental either to domestic or industrial consumers. No deleterious effects from the presence of fluoride ion in water, other than mottling of the tooth enamel, have become apparent in the numerous communities studied which are served with water naturally containing concentrations of fluoride ion in excess of 1.0 ppm.

The same favorable situation prevails in communities which are served waters treated to have the optimum fluorine concentration of about 1.0 ppm. Many industries are located in these communities, including chemical industries, breweries, bakeries and soft-drink bottling plants, for which water quality is important. No unfavorable effects upon industrial processes have been reported, except that ice made from fluoridated water in Charlotte, N. C., was "brittle". No such effect has been reported from the other communities where ice is manufactured and which are served by water supplies containing a fluoride-ion concentration of 1.0 ppm or more.

Fluoride compounds have been handled in the chemical industry without any difficulty, as long as dust is minimized and ordinary precautions are taken by using dust respirators and rubber gloves. No occupational hazard has been disclosed in the handling of fluoride compounds at water-treatment plants, provided dust-control equipment is used, and dust respirators and rubber gloves are worn by those handling the solid fluoride compounds.

Fact 5—New Problems of Philosophy are Involved in Fluoridation

Fluoridation of the public water supply on an empirical basis, to provide mass partial control of dental caries, is now an authoritatively recommended practice. Recommendations generally include the requirement that the practice of fluoridation must have the approval of local dental, medical, health and other governing agencies, and must meet the requirements set forth by the state health authorities. Primary consideration is given to the continuation of fluoridation on an experimental basis.

The most recent approval of fluoridation was that, late in 1950, of the American Dental Association. The practice has received the recommendation of the U. S. Public Health Service, the State and Territorial Dental Directors, some State Departments of Health, some State and local dental societies, and other groups. It is reported that the American Medical Association has not taken a stand for or against the practice of fluoridation.

At its inception, the practice of water fluoridation was frequently termed "mass medication". It is now recognized that the term is incorrect; the dosage is not administered to treat or cure a disease, but to prevent it by helping nature to build more resistant teeth. Water fluoridation should clearly be termed "supplemental treatment". It is, specifically, the adjustment of the fluoride-ion content of water to the optimum level.

The objections to the practice of fluoridation are generally of three types: one is that fluoridation may require State legislative action; another is that fluoridation should be opposed as a matter of religious principle; and the third is that no action should be taken until research has proven that no adverse physiological effects can be produced.

Cox and Ast (7) have answered three questions on the basis of present information. These are

1. Will fluoridation do any good?
2. Will it do any harm?
3. What will it cost?

The reported data from areas where the communal water supply naturally contains the optimum concentration of fluoride, as well as from areas where controlled fluoridation is being practiced, amply demonstrate the benefits to dental health from this procedure.

No evidence of an adverse physiological effect on children or adults, due to use of drinking water with a fluoride content of 1.5 ppm or less, has been found. McClure's studies covered height, weight and bone-fracture experience of young men examined for selective service. The Newburgh-Kingston study included general physical examinations; blood and urine analyses; X-rays of hands, forearms and tibias, and special eye and ear examinations of the children in both those cities.

The 5-15¢ per capita per year cost of water fluoridation is among the least expensive of public health practices today.

Black (8) has analyzed the basic issues which apply to this problem as those of value, right and obligation. His conclusions concerning these basic philosophical principles may be summarized as an attempt to prove, from purely ethical considerations, that "society has the right to expect that those things be done which contribute to the public welfare, provided they are reasonable and practical." His evidence also leads to the conclusion that "decisions on matters of major policy which affect the public welfare should be made by those professions or groups most qualified from the standpoint of training and experience to make them."

The simple and summary statement of policy and procedure by the A. W. W. A. with reference to the fluoridation of public water supplies is in accord with these principles. The statement, in effect, says to the medical and dental professions: "If, in the light of all available evidence, you believe that the fluoridation of public water supplies is in the interest of group health, the water-works industry stands ready, as it always has and always will, to participate with you in its practical realization."

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FLUORIDATION EXPERIENCE IN NEW BRITAIN

BY GEORGE W. WOOD*

[*Read September 10, 1951.*]

One of the most important decisions for a water utility to make today is whether or not it should treat its supply with sodium fluoride. Like any other new idea, such treatment produces a great amount of discussion. Several years ago the use of chlorine precipitated a similar condition. It is not my intention in this paper to attempt in any way to settle this question for you, but only to relate our experiences in New Britain and make a few general observations.

No two communities are exactly alike. Some are highly residential, while others are highly industrialized. The type of residents varies greatly also. There is a variation in the character of the water and the general layout of the entire system.

From experience obtained in several test installations and from several communities in Wisconsin the reasoning is that treatment with sodium fluoride will lower the amount of tooth decay in children. Sodium fluoride treatment is effective on only a small percentage of the individuals in any community. Naturally the question arises as to why the entire supply should be treated if only a small percentage of the population is affected. According to some people, the purpose of sodium-fluoride treatment is to improve the health and, therefore, the cost should be borne by the health department.

There probably are many other arguments for and against sodium-fluoride treatment in addition to the ones already mentioned. Each community will have to decide for itself whether to treat or not. The city of New Britain, according to the 1950 Federal census, has a population of approximately 75,000. The Board of Water Commissioners is a municipal corporation, supplying the city and the neighboring town of Berlin with water. The total number of people supplied is approximately 80,000.

The source of supply consists of three surface supplies and a

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ground-water supply. Both supplies are of good quality, with low pH, low turbidity and low hardness. The entire surface supply is treated in a 10-mgd, Morse-type, rapid-sand filtration plant, constructed in 1940. The ground-water supply is generally delivered directly into the distribution system, with chlorination as the only treatment.

It was in September, 1947, that one of the Board members first brought up the question of sodium-fluoride treatment. The local health officer was asked for his opinion. He was not in favor of the treatment's being adopted, as such treatment was still in the experimental stage.

The matter was tabled and nothing more was done until about the middle of 1949. The Board received a letter from the local health officer recommending the use of sodium fluoride in the water supply. In the ensuing months the problem was discussed and considerable information collected. The members of the Board were not against the treatment, but wished to procure all possible information and also to procure all possible backing before committing themselves.

Favorable letters were received from Dr. Dumont, the local health officer, the New Britain Dental Society, the New Britain Medical Society, Dr. Stanley H. Osborn, Commissioner of Health for the State of Connecticut, Dr. Franklin M. Erlenbach, Chief of the Division of Dental Hygiene of the State of Connecticut, and Mr. Warren J. Scott, Director of the Bureau of Sanitary Engineering of the State of Connecticut. In addition to these letters of approval, information was received from the city of Milwaukee, Wis., in regard to their experimental work with sodium silicofluoride. The city of Charlotte, N. C., was also contacted for information as to their experience with sodium fluoride and manufactured ice.

In November, 1949, the Board voted to include an item in the 1950-51 budget for sodium-fluoride treatment. The procedure in New Britain is to prepare your budget, have it approved by the Board of Finance and Taxation, then approved by the Common Council and finally by the Mayor. There was no serious opposition anywhere along the line. In spite of the publicity on the matter, only one letter of objection was received and that was unsigned. In March, 1950, permission was granted by the Common Council to purchase and install the necessary equipment. This equipment was purchased from

Wallace & Tiernan Co., Inc., of Newark, N. J., at a cost of $3,642.00.

Our system of supply is such that two units were required—one for our surface supply and one for the ground-water supply. Fortunately, the installation problem was not difficult. The three surface supplies are all treated at one point, namely, the filtration plant. The head-house at the plant houses the chemical dry-feed machines and chemical storage. The storage room comprises the entire top floor of the building and, after considerable study, it was decided to install this new equipment on this floor.

A section of this floor was partitioned off for the equipment. A connection was made to the high-pressure water system for a water supply. The discharge line was run down to the first floor, to a concrete control chamber. Lime and chlorine are also introduced into the water in this same chamber. A power connection was no problem at all. The reason for segregating this equipment was to confine the toxic dust to a small area, hence it could easily be carried outside the building through a ventilator system.

As the ground-water supply is generally delivered directly into the distribution system a second installation was necessary. Here again we were fortunate in our installation problem. At this location there are two large pumping stations, one of which was constructed in 1922 and now houses only a Venturi meter and a chlorinator. There is plenty of room in this building for the equipment and chemical storage. However, this equipment has not been installed, as there is still a small amount of work to be done. While this installation is being completed the water from this source is being pumped to the filtration plant so that the entire supply can be treated. The water supply for this unit will be connected to the discharge side of the pumps and the discharge from the unit will be connected to the pump suction.

Chemical bids are received in December each year. In December, 1950, however, no bids were received for sodium fluoride, due to uncertainty as to manufacture, availability and changing prices.

As we had been able to purchase two small lots of the chemical, however, on December 7 sodium fluoride was introduced into a city water supply for the first time in New England. It was decided to treat at a rate of 0.5 ppm for a short time. Eight days after starting

samples were taken at seven points in the distribution system. Six of these samples tested at 0.5 ppm and one sample at 0.6 ppm. One of these sampling points is about 4 miles from the filtration plant.

Due to the difficulty in obtaining the chemical, the treatment was stopped after about two weeks. It was not until April of this year that an adequate supply of sodium fluoride could be obtained. Treatment was resumed and has been continuous ever since at the rate of 1.0 ppm.

Very close checks are made throughout the whole system. Tests are made daily at the filtration plant and at the city laboratory. Additional tests are made each week by the State Department of Health at the filtration plant. Frequent tests are also made on samples from the various sampling points in the distribution system.

It might be well to insert a word of caution at this point. The use of sodium fluoride for this type of treatment is comparatively new. The chemical must be fed at a low rate and maintained within very narrow limits. The chemical must have the ability to flow readily and the equipment must be able to feed accurately at these low rates.

In addition to segregating the equipment in the head-house and ventilating to the outside, further safety measures were taken by furnishing the operators with proper respirators and rubber gloves. It was estimated that the equipment and its installation would cost about $5,000.00, and it appears from the costs to date and the possible cost of the remaining work at the ground-water supply that our estimate was a little high. No additional labor is required, as the present force of men can certainly handle one more dry-feed machine and make a few more tests each day.

The cost of sodium fluoride delivered to the plant has averaged about 12.25¢ per lb. It takes about 19.5 lb of chemical to every million gallons of water. Based upon a 10-mgd consumption, it would require 195 lb per day or 71,175 lb per year. At 12.25¢ per lb the cost per year would be $8,894.00. Supplying a population of 80,000 figures a per-capita cost of slightly over 11¢ per year.

The original installation consisted of a Wallace & Tiernan, type A-552, dry chemical feeder with solution mixing chamber. The feeder was mounted on a 46″ x 38″ platform scale. After this feeder had been in use for a while, the equipment manufacturer asked us to try

out a type A-635 dry chemical feeder which we are now doing. This type of feeder is more compact than the first unit, with the feeder, hopper and scale situated on top of the mixing chamber. This unit eliminates the large platform scale. Both units have worked successfully.

By using the proper equipment and the proper chemical, and by making the required tests, treatment with sodium fluoride should not be any more difficult than treatment with any other chemical.

In closing, I should like to express my appreciation for the assistance and coöperation received from all individuals connected with inaugurating sodium-fluoride treatment in New Britain.

PROGRESS AND EXPERIENCE WITH FLUORIDATION IN CONNECTICUT

BY WARREN J. SCOTT*

[*Read September 10, 1951.*]

The Connecticut State Department of Health under the leadership of its commissioner, Dr. Stanley H. Osborn, has for a number of years been a strong advocate of fluoridation of water as a measure of prevention of dental decay. Subsequent to the discovery that persons using natural waters containing the optimum content of fluoride suffered far less tooth decay than other persons, Dr. Osborn studied the evidence along with the chief of the division of dental hygiene and urged the adoption of this protective measure. Our first installation in the state came close on the heels of the installation in Grand Rapids, Mich. Equipment for adding sodium fluoride was placed in service at the Southbury State Training School on April 30, 1945, and has been in continuous use ever since—a period of about 6½ years.

Attitude of the Water-Works Officials

Despite the urging of the state department of health, later followed by the state dental society, the Connecticut Public Health Association, the Connecticut health officers' conference and others, many of our Connecticut water-works officials have maintained an attitude of watchful waiting. Action by the American Water Works Association has been described elsewhere.

The writer at the annual meeting of the American Public Health Association last year was impressed by an account by Prof. M. Starr Nichols of the University of Wisconsin. In Wisconsin, as many of you know, the installation of fluoride treatment on public water supplies has progressed by leaps and bounds. The last information I have is that fluoride is being added to 57 public water systems in that state. Prof. Nichols pointed out that in Wisconsin, where many public water supplies are derived from deep wells, there were already

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present varying amounts of fluoride in a considerable number of the water supplies. While it is true that high content of fluorides causes mottling of the tooth enamel—not decay—it was found by dental studies in the state that tooth decay was far lower in those communities with the optimum amount of fluoride—about 1 ppm—without any mottling or discoloration. He stated that they had a natural proving ground as to the effectiveness of the presence of the fluoride ion in preventing tooth decay. That, he said, was the reason why the advantage of artificially introducing fluoride in the water, when there was a fluoride deficiency, sold so rapidly in Wisconsin.

It seems important to bear in mind that fluoride treatment of water is not really medication. It is placing in the water a substance that is already present in natural waters in many sections of the country. So far as the writer has been able to ascertain, there have been no adverse effects on the human system found from the presence of fluoride in those sections of the country where people have for many years been using natural water with fluoride in it, other than possible mottling of the enamel when the content of fluoride becomes excessive. In the August, 1951, issue of the A.W.W.A. Journal, Cox and Ast point out that a survey by Hill, Jelinek and Blayney showed that approximately 1,000,000 persons in this country are served by public water supplies containing 1.0 to 1.5 ppm fluoride ion and an additional 1,640,000 persons are served by supplies containing 1.6 to 5.1 ppm fluoride ion or higher. In Connecticut, we have to date found no appreciable quantities of fluoride in our natural waters. A few deep wells have shown small but not significant amounts.

In our state, of 109 water systems furnishing water to the public and designated as so-called *public* water systems, 27 are owned by municipalities or municipal districts and 82 are owned by private companies or individuals. The assumption of the cost of fluoridation may be easier to work out in the case of a municipally owned supply but private companies can coöperate in the preparation of plans for paying the cost of this protection. Certainly, plans must be developed for financing on the most reasonable terms that can be worked out. Private companies undoubtedly do not wish to lag behind municipal systems in the character of their public service, but are entitled to reasonable compensation.

Connecticut Installations

Mention has already been made of the installation at Southbury, started on April 30, 1945, where sodium-fluoride powder is added to water in a 50-gallon monel-metal solution tank and pumped into a discharge line from two gravel-packed wells, that in turn empties into a large concrete storage tank. From the tank, water flows to the distribution system. Proportioneers chemical solution feeders are used. The average daily water consumption is approximately 200,000 gal, serving a population of about 1,800. A second installation of similar type was made on a second large state-institutional supply, the Mansfield State Training School, in November, 1950. Here the average daily water consumption is approximately 200,000 gal, serving a population of about 1,700.

Both of these installations have operated successfully with an average fluoride content of 1.0 ppm in the delivered water. The observations of reduction in dental decay at the Southbury State Training School have shown a substantial accomplishment. These institutional children did not receive the benefit of the treatment in as low an age group as, say, at Grand Rapids, Mich., where the reduction in dental decay as the children grow under the treatment may reach higher than 60%; however, the early Southbury studies indicated a reduction of at least 30%. The only mechanical troubles were in the early stages at Southbury where, because of a very high operating pressure in the main, it was found advisable to replace solution hose with pipe; and in connection with some corrosive action of the solution on the solution tank, new tank materials were tried. Of course, the solution is greatly diluted when it enters the main.

The first large installation in Connecticut was on the municipal water supply of New Britain on December 7, 1950, where an average daily flow of about 9.5 mil gal, serving a population of about 80,000, is now treated. This installation has been described to you by the chief engineer, George Wood, to whom the credit for ironing out the details is due.

The latest installation is on the municipal water supply of the Cromwell Fire District, which was made under the direction of Dr. Frank H. Couch, president of the district. Here, there is an average

daily flow of approximately 180,000 gal serving about 2,500 persons. This installation is more unique than our other small installations. A so-called "saturator" tank is used. This operates on the principle that water will take up only so much sodium fluoride in solution. The chemical, instead of being in a powdered form, is in the form of small crystals, resembling sand. The crystals are dumped into a 50 gallon, enamel-lined steel tank. Downward from the water surface of the tank through to the inside of the pile of crystals on the bottom extends a 2-inch pipe with a strainer in the bottom. A small hose extends inside the pipe. The solution around the bottom of the pipe and the hose, which are surrounded by the crystals, becomes saturated and analyses have shown that the solution contains about 4.0% fluoride. Of course, the concentration after dilution and proportioning in the main is such that the content is only 1.0 ppm of fluoride. The hose is connected to a small Proportioneers chemical feeder, electrically operated, which pumps the solution into the water main in the pumping station. The water level in the tank is maintained by a constant-level float valve. The use of this "saturator" does not necessitate any batch mixing of chemical solution. The chemical is simply dumped into the solution tank. It may be sufficient for two to four weeks. When the level of crystals is observed to be low, more crystals are added. This installation, while in operation only since June, 1951, appears promising for small systems. The crystals are easier to handle and the need for measurements is kept to a minimum. Observations are continuing.

Procedures and Tests

Under Connecticut law, plans for new water-treatment plans must be approved by the state department of health and the qualifications of operators of water-treatment plants are subject to the approval of the state department of health.

The Connecticut State Department of Health has forwarded to water officials the following memorandum:

> "In connection with the addition of fluoride to water supplies the State Department of Health asks that the following procedures and precautions be carried out. It is important that proper control measures be exercised. The objective is to carry 1.0 p.p.m. of

fluoride in the treated water, with a maximum not exceeding 1.3 p.p.m.

"1. Approval of the equipment for adding fluoride and of the installation arrangements must be secured from the State Department of Health. Application should be made to the bureau of sanitary engineering of the department.

"2. Arrangements must be made for the starting up of the installation under the immediate supervision of the State Department of Health.

"3. Testing equipment must be purchased for the purpose of carrying out daily fluoride determinations by the water utility. The State Department of Health will furnish instruction in the use of the testing equipment.

"4. In addition to the daily analyses by the local water utility, small containers will be furnished by the State Department of Health and the water utility is asked to forward samples of fluoridated water four times a week for the first month to the laboratories of the State Department of Health for check analyses. Thereafter it is asked that samples be sent in to the laboratories once a week for the next two months. Then the number of samples may be reduced but in all cases at least monthly samples shall be sent in to the State Department of Health for analysis.

"5. In larger installations where there is likely to be a dusty atmosphere in connection with frequent filling of tanks or hoppers with large amounts of fluoride powder, some plan of mechanical ventilation may be desirable. The powder should not be breathed in large amounts.

"6. For small installations ventilating equipment is not needed but there should in all cases be purchased an inexpensive approved type of dust mask which should be used to protect the workers against dust when they are handling the powder. These should be stored away from a dusty atmosphere when not in use. Individual masks should be provided for each worker.

"7. Workers should wear gloves of the impervious type when

they are handling the chemical and should wash their hands after the handling of the chemical and before eating. A lightweight leather glove with gauntlets or a glove made impervious by impregnation with rubber or other flexible plastic material would seem to afford good protection.

"8. The fluoride chemical should be properly stored and kept separate from other chemicals so as to avoid errors in handling. The blue color of Nile blue sodium fluoride powder is a desirable protective feature as against the color of the white sodium fluoride powder."

The state department of health has exercised close supervision over the sodium-fluoride installations in use. David C. Wiggin, Jr., sanitary engineer with the department, supervised much of the early work and other sanitary engineers in the bureau have also greatly aided in promoting successful operation. It goes without saying that the state-institutional and municipal officials have exercised immediate supervision and they have coöperated to the utmost.

In the case of one small installation, it may be of interest that a local pharmacist was employed to help in making the necessary tests and did a good job. Sometimes, a local high-school chemistry teacher or other trained person may be worked in to do testing, as an aid to personnel who are not specially equipped to do such work or who have not the available time. With larger supplies or where there are filtration plants, testing and supervision do not ordinarily furnish much of a problem. On supplies where there is a large number of sources, as on at least two of our Connecticut water systems, supervision and testing become more burdensome and may necessitate employment of an additional worker—at least for part time.

Costs

Perhaps there has been too much tendency in some cases to mention only chemical costs when considering fluoride installations. In many instances, as cited by Mr. Wood of New Britain, this may be by all odds the major cost. However, some systems, particularly those served by several sources and without buildings to house treating equipment, may require considerable expenditure for structures to

house equipment, as well as several layouts of equipment to be installed at different points and, as already stated, added cost for supervision. Power costs are usually small but must be allowed for.

Mr. Wood has pointed out that in New Britain the installation cost of about $5,000 was small, in view of the size of the supply, and the amount set aside for amortization and depreciation is very low. Also, no new personnel was employed for supervision. On the other hand, we have an estimate from a large water company, supplying water from five sources, which considers that the purchase of chemicals, amortization and depreciation allowance for housing and equipment, and provision of supervision, power and other items will bring its cost to 35 to 40 cents per capita each year.

Obviously, per-capita daily use of water, as tied in with industrial use, metering, etc., will affect the cost. In Cromwell, for example, the per-capita consumption of water is only about 72 gal per day. There, the cost of chemicals is not estimated to exceed 7.2 cents per capita per year. The cost of installation was $820. Because of lack of available supervisory personnel and the small population involved, a rather large figure of 10 cents per capita per year has been estimated for supervision. Cost of power is estimated as 2.2 cents per capita per year and allowance for amortization and depreciation is estimated as 3.8 cents per capita per year. Thus the total per-capita annual cost is 23.2 cents. About half of this cost, it will be noted, is for extra supervisory labor.

Sodium fluosilicate and other chemicals have been employed elsewhere in place of sodium fluoride. Sodium fluosilicate is less soluble than sodium fluoride, but can be used and, at present, costs less than sodium fluoride. The available supply of sodium fluoride in the nation is short, if the growing demands for the chemical are taken into consideration. There appears to be, however, considerable likelihood of increasing the supply of sodium fluosilicate, so that the number of sodium-fluosilicate installations is likly to be on the increase. Per-capita annual costs as low as 4 or 5 cents have been quoted for sodium-fluosilicate installations. It might be of interest to comment that, in the case of the 57 fluoride installations on Wisconsin public water supplies, 36 are for application of sodium fluoride, one makes use of hydrofluoric acid, 15 are for application of sodium fluosilicate

and 5 make use of hydrofluo-silicic acid. In Connecticut there has been some interest in use of sodium silico-fluoride or sodium fluosilicate.

In summary of costs, it may be said that our experience indicates that average annual costs will run from about 10 cents to 20 cents per capita per year, including chemical, installation, depreciation, supervision and other items. In isolated cases, where special factors exist, costs may run as high as 35 or 40 cents per capita per year.

Proposed Legislation

A representative in our 1951 General Assembly introduced a bill to make the installation of fluoride treatment of public water supplies compulsory. The bill as finally drafted and heard before the Public Health and Safety Committee of the General Assembly was known as Substitute for House Bill 857 and reads as follows:

"An Act Concerning the Fluoridation of Public Water Supplies

"Be it enacted by the Senate and House of Representatives in General Assembly convened:

"Section 1. The inclusion of sodium fluoride or other fluorides in public water supplies for the reduction of dental caries is determined to be in the public interest, health and welfare.

"Section 2. Each person, firm and corporation whether public or private, supplying water to the public on and after January 1, 1953, shall cause sodium fluoride or other fluorides to be introduced into such water supply in such amounts and in such manner as the state department of health shall deem necessary for the effective prevention of dental decay and which said department, by regulation, shall provide.

"Section 3. The state department of health shall have jurisdiction over all public water supplies for the purpose of carrying out the provisions of section 2 of this act.

"Section 4. The cost of the necessary equipment and installation to carry out the provisions of section 2 of this act may be included in the operating expenses of any such person, firm, or corporation under the jurisdiction of the public utilities commission, in such manner as may be approved by said commission, and such costs

may also be included in the rate base and operating expenses of any municipality or municipal district supplying water to the public."

Opposition at the hearing was registered by attorneys for some of the water utilities, who objected to the compulsory features of the proposed law. The bill was not passed, but the 1951 General Assembly did pass House Joint Resolution No. 75 which reads as follows:

"Resolved: That House Bill 857, entitled 'An Act Concerning the Fluoridation of Public Water Supplies,' shall be referred to the Legislative Council for its study and consideration. The Legislative Council shall report its findings and recommendations thereon to the 1935 session of the General Assembly."

The legislative council referred to is an interim body, composed of members of the Senate and House of Representatives. Presumably, this body will report to the next session of the General Assembly in 1953.

It might be worth mentioning that the state of Wisconsin has enacted legislation authorizing water utilities and municipalites to include the cost of fluoride installations in their charges for water. The Wisconsin laws are known as Chapters 325, 327 and 328 of the Public Acts of 1949.

Future Progress

It appears to the writer that the evidence indicates there is a definite public-health advantage in the addition of fluoride to public water supplies. It is true that there are other methods of affording protection, but none of them is so universally effective as the protection afforded by water treatment. The dental experts mention that the benefits begin at birth and continue through the period of formation of the first and second teeth. The rising generations will have sounder teeth with less suffering and less cost. It is true that a large proportion of the water is not taken into the body, so as to play a part in the prevention of tooth decay, but even then the over-all results from treatment of the public water supplies are least expensive to the public and most effective.

In concluding, it is of interest to report that the management of

one private water utility in our state, which also operates other utilities, recently advised a community that because of the limited cost involved in this particular case, the water utility would for the present assume the cost, reserving the right to incude the cost in any future application for increased rates, provided the local community and the local dental and medical associations went on record in favor of the installation. If the public wants treatment of the water for prevention of tooth decay, the water official should adopt a coöperative attitude in working out a satisfactory plan of treatment in the interest of good public relations and promotion of the public good. There must, of course, be developed methods of defraying the cost, whether by outright assumption of the cost on a municipally owned supply, possibly by adjustment of its water charges if necessary, or by adjustment in water rates, if needed, for a private utility, or by annual payments to a private utility by the municipalities served, rather than through water-rate charges, if this is preferable.

A RAPID METHOD FOR THE DETERMINATION OF FLUORIDES IN WATER SUPPLIES

BY LAZARUS RUBIN*

[*Received January 23, 1952.*]

While the method for the determination of fluoride described in Standard Methods (9th edition—1946) has been found satisfactory, need arose for a more rapid method for use in installation and adjustment of chemical-feed machines for the fluoridation of water supplies. The method devised is a simple modification of the standard method, but has the advantage that the reading is taken at the end of five minutes instead of one hour. In addition, permanent liquid standards have been prepared for this method and so chosen that the color range in the area from 0.8 to 1.4 ppm fluoride is sufficiently wide to enable non-technical personnel to make color readings with greater ease.

Reagents

The fluoride reagent is prepared as follows:

(1) *Zirconium Oxychloride*:—Dissolve 0.43 g. zirconium oxychloride ($ZrOC1_2.8H_20$) in 50 ml distilled water.

(2) *Alizarin Red S*:—Dissolve exactly 0.1 g. alizarin sodium monosulfonate (alizarin red S) in exactly 50 ml distilled water.

(3) Prepare 500 ml of a 1.55 N hydrochloric acid solution (69.8 ml HCl, sp.gr. 1.19) and 1,000 ml of 1.55 N sulfuric acid solution (44.4 ml H_2SO_4, sp.gr. 1.84). After cooling these solutions, mix 480 ml of the hydrochloric acid solution with 520 ml of the sulfuric acid solution.

(4) Pour the 50 ml of alizarin red solution slowly with stirring into the 50 ml of zirconium oxychloride solution. Place exactly 70 ml of the mixed alizarin-zirconium solution in a liter flask and make up to the mark with the mixed-acids solution. This reagent should be allowed to stand 24 to 48 hours in the dark before use. If thus stored, it will be satisfactory for use over a period of two to three months.

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Procedure

One hundred ml of sample are poured into a 250-ml glass-stoppered Erlenmeyer flask and 5 ml of the reagent, accurately measured from a volumetric pipette, are added. After shaking, this solution is poured into a tall, 100-ml, Nessler color-comparison tube. Exactly five minutes after the reagent has been added, the color is compared with that of permanent color standards. Where 50-ml Nessler tubes are used, the quantity of reagent is reduced to 2.5 ml. The test may also be carried out directly in the tube if a flask is not available.

Permanent Color Standards

Permanent color standards are prepared from two solutions commonly present in a water laboratory, potassium chloroplatinate and cobaltous chloride.

Cobaltous Chloride: Dissolve 12 grams of $CoCl_2.6H_2O$ in a small volume of distilled water. Add 100 ml concentrated hydrochloric acid and dilute to one liter with distilled water.

Potassium Chloroplatinate: Dissolve 2 grams K_2PtCl_6 in 300 to 400 ml of distilled water, containing 100 ml of concentrated hydrochloric acid, and dilute to 1 liter with distilled water.

Measure into 100-ml Nessler tubes the volumes of chloroplatinate and cobalt chloride indicated in Table 1 and make up to the mark with distilled water. Mix thoroughly. For use with 50-ml tubes, one-half the respective quantities of platinate and cobalt can be used.

Table 1.

Fluorides reading (ppm)	K_2PtCl_6 solution (ml)	$CoCl_2.6H_2O$ solution (ml)
0.0	2.0	24.0
0.6	6.0	15.0
0.8	7.5	12.0
1.0	8.6	9.0
1.2	11.0	5.5
1.4	12.5	2.5

It has been the practice of the laboratory to check each batch of reagent against a known fluoride concentration. We have found

that there is some lack of uniformity in the various batches of reagent, the reason for which is not apparent. However, this reagent has been used by both technical and non-technical personnel at an experimental fluoridation installation in Massachusetts since 1946 and has given results that check quite closely with the standard method. It has also been used during installation and adjustment of fluoridation equipment. Results may be expected to be accurate within 0.1 ppm fluorides.

Interferences

It has been found that, in general, the interferences with the test by the various ions in water are about as indicated for the standard test in Standard Methods, with the following additions:

Free chlorine. Where a water supply is chlorinated, it must be dechlorinated before the test for fluoride can be carried out. This can be done by adding either 0.5 ml sodium arsenite (0.5 gm per 100 ml), as in the OTA test, or 0.5 ml of 0.025 N sodium thiosulfate, shaking the sample, and then adding the fluoride reagent.

Temperature. It has been found that, for water temperatures of 45°F. and over, there is little interference with the reaction. For temperatures lower than this the results tend to be low by about 0.05 ppm fluoride. This can be overcome by warming the tube briefly.

GENERAL FORESTRY PRACTICES

BY RALPH C. HAWLEY*

[*Read at Superintendents' Round Table, Sept. 11, 1951.*]

This paper presents a brief summary of the principal activities essential in a forestry program for Water Boards.

Forested and Open Land. The natural starting point for the members of a Water Board, when they first become interested in forestry practice, is to make a survey of their holdings, to find out how much forested and how much open (unforested) land they possess, and what the character and condition of the forest land may be. Since most Water Boards already have base maps of their holdings, the task of sketching in on these maps the different types of cover should not be difficult or expensive. After this survey is finished, the next question of interest is how each type of land should be treated. Certain areas will be needed as sites for buildings and storage yards and for other administrative purposes, but where extensive watersheds are owned, there will be relatively large areas of land best kept under a forest cover. It is upon these lands that forestry should be practiced.

Forest Planting. Fields and other bare areas present a special problem. It is quite generally accepted that such areas, except where needed for administrative purposes or so located as not to be required for watershed protection, should be reforested. The reasons for this are so well understood that it appears unnecessary to spend the time here to discuss them.

Past practice on watersheds in New England has inclined toward the artificial planting-up of these open lands with such trees as pines and spruces. Most Water Boards in New England are well advanced on the program of planting their open fields or may even have completed this part of the program. The New Haven Water Co., for example, which started planting in 1909, by 1940 had planted around 2,900 acres and had covered nearly all the open areas which it was

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desired to plant. This company has been selling forest products from the older plantations for nearly 15 years. Other Water Boards also are harvesting material from their plantations.

For those Water Boards still having bare lands, the planting of white and red pines and Norway and white spruces is a desirable project to receive early attention. The species planted should depend on soil conditions and geographical location.

Forest planting is an operation which requires an initial outlay for trees and labor, but is justified by the protection afforded the watershed. Furthermore, the outlay should be returned ultimately through sale of forest products from the plantations.

However, the planting of bare lands is only part of a forestry program. In fact, usually only a small proportion, estimated at less than 15%, of the average watershed requires such work.

Next, and most important, is good management, both of the planted forest and of the natural forest found on the watershed. Good forest management on watersheds may be summarized under two headings:—protection and cutting operations.

Protection. The forest, of course, should be protected, since it in turn improves the quality of the water, and decreases the danger of soil erosion and rapid runoff after storms. Protection of the forest is needed against fire, insects, plant diseases, livestock and trespass.

Fire protection is essential on any watershed and can be obtained most efficiently through coöperation with town and state fire officials. Fifty years ago, quite a common practice was purposely to burn over each year the areas adjoining streams and reservoirs. The effect on soil erosion and surface runoff of water was bad. Today the desirability of fire protection is well understood and practiced by Water Boards.

Insects and diseases of plants, as well as of men, are always with us. Practical control of these pests is secured by reporting any evidence of their activity to the proper state officials, such as the state entomologist or state pathologist or extension forester, and following their advice for control.

The injury to watersheds by pasturing domestic animals apparently is not too well understood by Water Boards and its damage to water supplies is likely to be underestimated. Areas closely cropped

by grazing livestock are subject to soil erosion and to rapid runoff of precipitation, in addition to possible pollution of the water. As compared to a forest in which grazing has been stopped, a closely cropped pasture may have an immediate surface runoff of precipitation 50 times greater. With the ever-increasing interest in and knowledge of the factors influencing water supply, a Water Board which continues to maintain bad examples of over-grazed forest and fields close to streams and reservoirs will sooner or later receive adverse public criticism.

Cutting of Forest Products. Cutting of products is the most important of all forestry practices on a watershed. In the last analysis, good forest management will be judged by the cutting operations and by the forest thereby created and maintained.

At one time it was thought that the denser the forest, the better it was as a watershed cover. Nowadays it is recognized that the advantages of a forest cover, from the standpoint of soil protection and maximum water yield from a given area, are greater when the forest is kept in a relatively open condition. This can be secured by repeated cuttings at intervals of 10 to 20 years. These cuttings never entirely remove the forest over any large area, but result in providing openings through which a larger percentage of the snow and rain can reach the ground, rather than being held on the trunks and crowns of the trees.

Hence, frequent cuttings should be made as a regular program in good watershed management, entirely aside from the question of what revenue can be obtained from such cuttings.

However, there is no reason why, as the forest becomes old enough to contain trees of merchantable size, the cuttings should not be financially profitable, provided the cutting operations are arranged with that end in view.

To be financially profitable, cutting operations carried on by a Water Board should be on a piece-work basis or else on a stumpage basis—that is, the purchaser buys the wood and timber as it stands in the forest, and cuts and removes it himself. A large proportion of Water Board employees, having been hired for other qualifications, are not competent to perform woods operations efficiently. But oftentimes, in order to keep these men employed full time the year round,

they have to be put on woods operations (usually in the winter). The result is in nearly all cases a financial loss on that operation—the cost running anywhere from 2 to 8 times the cost if done by piecework by skilled woodsmen. In many Water Board operations there is too much clean-up of slash left after logging. Heavy slash on the ground is beneficial to water supply by lessening evaporation, decreasing surface runoff and increasing soil porosity. Much expense can be saved by leaving the slash after cutting right as it lies.

Technical Supervision

In handling the technical forestry problems involved in planning and carrying out the cutting operations, and in marketing products from the forest, the larger Water Boards usually find it advantageous to employ a full-time forester, who might well be made responsible for all land-management problems other than those relating directly to sanitation and water supply. Smaller Water Boards can secure advice from their state forestry departments and extension forester, from consulting foresters, or from such private companies, specializing in managing forest lands and marketing forest products, as Connwood, Inc., in Connecticut, or the New England Forestry Foundation.

SAWMILL OPERATIONS AND MARKETING OF FOREST PRODUCTS

BY P. A. SHAW AND A. J. CHRISTIE*

[*Read at Superintendents' Round Table, Sept. 11, 1951.*]

Good forest management is an important part of watershed management. Good watershed management consists, in part, of keeping the watershed covered as much as possible with tree growth.

For those of you who are not familiar with our set-up at Manchester, N. H., there follows a brief resumé. We shall use Manchester Water Works figures and forest conditions as being fairly typical of those in the Eastern pine area.

Our watershed covers an area of 43 sq mi or about 27,000 acres. At present we own over 6,000 acres of this area, or 22% of the total watershed. We are located in the southeastern part of New Hampshire, inland about 25 to 30 miles, which places us in the Eastern white-pine region. Our soil varies from sandy to sandy loam, which produces excellent pine growth.

Forest lands acquired to date have been in close proximity to our lakes, ponds and larger feeder streams, and we are now reaching out along our smaller tributaries to the more remote sections of the watershed. Most of the land has been farmed, cut over several times or burned, with the result that there is growth typical of this sort of land use. Approximately only one-third of our present forest land supports growth of measurable size—that is, trees that measure 5 in. and up, breast high. However, pine reproduction is natural for our area and cultural treatment will produce an uneven-aged, mixed forest. This is ideal for water-conservation purposes.

We have some nice stands of natural pine and more than 1,000 acres of white- and red-pine plantations, the trees varying in age from those planted last spring to some over 40 years old. We also have small arborvitae and spruce plantations. Our pine stands are growing

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at a rate that permits us to cut upward to 500,000 B. F. per year. This cut is much less than the annual growth increment.

In 1935, along with a sizeable land purchase around one of our smaller ponds, we acquired a sawmill. This was a water mill with a low head and poor tailrace conditions, set up to saw boxboard lumber. It was repaired and machinery was added, so that square-edge lumber could be produced. No more round-edge lumber than is necessary in a normal sawing operation should be sawn, because the price is so much less than for square-edge lumber. This repair work was done so that we could saw our own logs, which were removed in our several cutting operations. Up to the present time these have been almost, if not quite, entirely improvement cuttings.

This mill sufficed until this last year, when deterioration of the penstock and water-wheel had advanced to such a point that, due to breakdowns, the cost of sawing was too great. We decided to install a power unit of a capacity that would give us ample power to run all of the equipment necessary for producing well-manufactured square-edge lumber. This new power plant is a used Diesel unit of 137 hp. In the old mill, in addition to the water-wheel and in order to supply the necessary power, we also had a 30-hp gasoline unit and an electric motor. Thus the chances of a breakdown were three times as great as at present. One unit now runs the entire mill.

Machinery in the mill consists of a power winch, to haul the logs out of the storage pond, log carriage, head saw, double saw edger, live take-away rolls, sawdust blower, slab saw and a sawdust chain, which carries the sawdust from the edger saws back to the main sawdust pit, beneath the head saw. From this pit the sawdust is blown to the sawdust pile.

This mill is laid out in line. Slabs, square-edge boards, and round-edge boards unsuitable for squaring drop off the saw and travel to the tail end of the mill, where two men cut the slabs and clip and sort the boards, preparatory for the sticking operation. Round-edge boards that are to be squared are handled by a combination take-away and edger man, with the boards and resulting edgings taken care of at the tail end of the mill by the same two men who handle the live-roll material. We use seven men when sawing, including the two men sticking the lumber. Recently we have been able to get the sticking done by piece-work.

To date our remodeled mill has not been used a great deal, but it has been run enough to show that, with the same amount of sawmill help previously used, there is no reason why several thousand more feet of lumber should not be sawed per day. This will result in lower production costs and a shorter sawing season. The time saved can be used to great advantage on other watershed projects. With the new power we shall also be able to saw more uniform lumber.

On a watershed forest that has a definite forestry program, regular, judicious cutting should of course be done. For the past decade and a half all forest products cut on our property have been intergraded as much as possible. That is to say, our larger and better-grade logs go to our sawmill, to be sawed into boards and dimension sizes; the poorer and smaller trees and logs are utilized for cordwood, pulpwood, cooperage, excelsior wood, fence posts, buffer logs for parking areas, and blasting ties and poles for use by our construction crews. Good saw-milling starts in the woods. If good-grade lumber is to be produced, logs must be cut so that the greatest possible amount of high-grade boards will be sawn in the mill.

Let us assume that a tree has a 12-foot butt section with no visible defects, but from the viewpoint of taper and straightness a 14′ or 16′ butt log could be cut from this tree. This would increase production for the choppers and give the operator longer boards, which are desirable. However, beyond the 12′ length visible defects are plainly to be seen—black knots, checks, etc. If a 12′ log is cut, all possible grade in the log can be sawed out in the mill. But a 14′ or 16′ section, showing defects in the top 4 ft of the log, will of course show defects in the boards sawed from that log. Therefore, instead of getting largely selects and no. 1 common boards, the grade will be dropped to no. 2, no. 3 or no. 4 common, with the result that there will be a lower return for the low-grade material manufactured.

The next step for getting the most quality out of a log falls to the sawyer, who is the key man in a sawmill. After the log has been properly placed on the carriage and the first slab removed, careful attention should be paid to the face of each cut, as it goes through the saw. The best grade is taken from the outside cuts of a log and the nearer to the center a log is sawed, the poorer the grades which will develop. As the poorer grades appear, the log is turned until all of

the better grade is cut. This turning will perhaps result in less lumber sawed; but the resulting high grade will more than make up for the loss in volume.

The following is an example of sawing and selling on grade: In 1945 and again in 1947 the logs coming into our mill appeared to be better than average. It was decided to sell on grade, instead of mill run. Lumber was sold to the highest bidder, with the buyer to do the grading. It is important that lumber sold under these conditions go to a reliable outfit, preferably one that does its own dressing, so that grading can be done behind the planer. The 1945 mill-run price was $42.50 per thousand, FOB sticks. The successful bidder offered the following prices:

#2 common and better	$60.50 per thousand
#3 "	44.75
#4 "	39.45
#5 "	30.50

The average price from this sale was $46.26 per thousand board feet, or an increase of $3.76 per thousand.

Again in 1947 the successful bidder offered the following quotations:

Mill-run price	$ 60.00 per thousand, FOB sticks
D select and better	100.00 " "
#2 Common	85.00 " "
#3 "	70.00 " "
#4 "	52.50 " "
#5 "	30.00 " "

On this lot the final figures showed that the average price was $68.25 per thousand, or an increase of $8.25 per thousand.

There are several methods available for selling logs cut from the wood lot. One is by stumpage sales, where the standing trees are sold and the operator cuts, yards and saws them. Current stumpage prices range from $8. to $15., better prices being paid for exceptionally high-grade logs or lots that are very easy to log.

These stumpage sales with buyer to cut, unless very well supervised, leave the lot in very poor condition, with a heavy concentration of slash, and broken and destroyed young growth; so that under a forest program it is not advisable to operate in this manner.

Most portable sawmills produce a poorer quality of board than does a stationary mill and that, of course, lowers the sale value. Selling logs at roadside and selling them delivered at the mill are other methods of operating and give the operator only fair stumpage prices at best.

Example:

Stump to roadside costs:	$ 9. - $10.	chopping
	$ 6. - $ 8.	yarding
	$15. - $18.	roadside
Roadside prices	$25. - $28.	
Stumpage return	$10.	
Stump to mill costs:	$ 9. - $10.	chopping
	$ 6. - $ 8.	yarding
	$ 5. - $ 6.	hauling to mill
	$20. - $24.	delivered at mill
Price at mill	$30. - $34.	
Stump return, still	$10.	

For an additional cost of $15. to $18. for sawing square edge and sticking, plus $3. per thousand insurance, depreciation on equipment and normal repairs, and for drying this lumber from three to six months, the final product can be sold at present prices from $70. to $80. per thousand, F. O. B. sticks in mill yard. Thus, with this additional cost of $18. to $21. per thousand, the stumpage return rises from $10. per thousand to $25. to $28. per thousand. These operating costs are figured high and prices for lumber are mill-run prices for square-edge boards. As mentioned before, grading should give an even better return.

Whenever possible, sawing only the better-grade and largest logs is also important. With multiple forest markets this can be done by intergrading. The required time to log and saw a small log is nearly as great as that to log and saw a large log, although the larger logs produce more volume, wider boards and higher grade. This, of course, increases the final value of the finished product.

With an annual cut of 350,000 to 500,000 board feet a year, the profit from our mill operations ordinarily carries our cultural work, such as weeding, planting, pruning and other improvement work.

On a well-managed forest cuttings should be made regularly. This material will be of many different forms and sizes, ranging from very small and worthless growth, resulting from weedings and thinnings and which as yet is not marketable, to larger materials which are marketable in some form. As there will always be a market for logs and lumber, the problem is to find markets for the products removed in our cultural and thinning operations.

We are fortunate in Manchester to be near good markets. Recently these markets have absorbed most of the smaller and poorer-quality materials. This material is cut into cord-wood, excelsior wood (pine), pulpwood (hard and soft for the paper industry), wood for ground-wood-board, and cooperage, including wooden tubs, pails and barrels, as well as posts, poles, railroad and blasting ties, and slabs.

An analysis of these different markets shows that, whenever available, the paper companies and cooperage log markets are the best for the smaller cuttings.

The cooperage people use red and white pine, bought delivered at roadside or at their mill. They take lengths of 8 ft to 16 ft, with a top diameter of 4 in. This material must be long-jointed and sound, with sawed ends cut to the nearest joint. Only the internodes, or the clear portion between the branch whorls, are used. Cooperage is an excellent outlet for thinnings from our many pine plantations. Our cooperage operations in 1949-1950 were as follows:

We cut 14,610 ft. Chopping, yarding and hauling the logs 20 miles cost $224.23. Delivered price was $25. per thousand, which made a total return of $365.25 and a net return of $141.02, averaging $9.65 per thousand stumpage. Because of its small size, this material could not have been sold for logs. Material unsuitable for cooperage logs in this operation, due to short joints, was put into pulp-wood.

The demand for hardwood cord-wood has rapidly fallen off since the end of the second world war, with the result that only that wood unsuitable for the hardwood pulp-wood market goes into cord-wood. On this material we just about break even. The reasons for removing this low-quality wood are that it gives the pines an opportunity to grow and it reduces the amount of heavy slash left after an operation.

Excelsior-wood users and the pulp and paper industry call for the same specifications—namely, 4 ft long with sawed ends, a minimum of

4 in. at the small end, close-trimmed and sound. Species used are pine, poplar and basswood for excelsior and all species for pulp and paper. Prices for excelsior wood are $9. to $10. per cord roadside; for the pulp and paper industry, $15.25 to $16.75 per cord for soft wood (pine and hemlock) and $18.25 per cord for all species of hardwood. These pulp and paper prices are F. O. B. car, with roadside prices $3. to $4. less.

With wood being used for more and more purposes, it is just a matter of time and education before more material, that is now considered waste, will be used. Forest-products markets should continue to increase and improve.

During the last decade our Water Department has used a total of 353,000 board feet of lumber from our forests in various forms, at a substantial saving to the Department.

Many years will pass before all of our land is producing lumber of marketable size. However, as long as any one can now foresee, there will be a need for forest products in some form. What better place is there to grow this much-needed commodity than on our watersheds? Hundreds of thousands of acres of land are owned today by water works, both public and private, many more hundreds of acres being acquired each year. Lumber is being cut faster than it is growing. We realize that, primarily, this land is acquired for water conservation and protection. However, with few exceptions, it is good land, suitable for some kind of tree growth. What better opportunity, than in the practice of good forestry, is there for water departments throughout the eastern states to conserve their precious water supplies and at the same time help to maintain and preserve our only replaceable natural resource? Properly managed, and depending on the present condition of their stands, these forests will be a secondary source of income to them and at the same time be an asset to the national economy.

NURSERY PRACTICE AND WATERSHED PLANTING AT QUABBIN RESERVOIR

BY RUSSELL SNOW*

[*Read at Superintendents' Round Table, Sept. 11, 1951.*]

Quabbin Reservoir, the largest domestic water-supply reservoir in the world, is located in the west central part of Massachusetts, in what was formerly known as the Swift River Valley, lying between Springfield and Athol. It was designed for the purpose of extending Boston's existing water-supply system, which was rapidly becoming inadequate as a result of inclusion in the Metropolitan District Water Supply System of the suburban areas surrounding the city of Boston.

This project was started in 1926 and, during its construction, approximately 83,500 acres of land were acquired for watershed protection. This area included all of the towns of Enfield, Greenwich, Prescott and Dana and parts of the towns of Ware, Belchertown, Pelham, Shutesbury, Wendell, Orange, New Salem, Petersham, Barre and Hardwick.

Of this area, some 10,000 acres consisted of open land, brush land, cut-over timber land and inferior types of hardwood sprout-land. Rather than allow this area to grow up to brush and inferior hardwood forests, it was decided that, under a well-planned forestry program, it could be developed into a forest of considerable future commercial value, as well as an added protection to the water-shed of the reservoir.

The extent of the forestry work required for reforesting such a large area was evident and it was important to get started as soon as possible.

Therefore, in 1934, when the project was well under way and the greater portion of the watershed land had been acquired, a forestry department was established and plans were made for a general forestry program, to be carried on in conjunction with the construction of the reservoir. It was decided to establish a nursery, to produce our own planting stock, in view of the fact that several million trees would be

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required. The first step was the selection of a suitable nursery site in a convenient location within the reservoir area. This was done by investigating numerous areas and running soil tests, to determine their suitability for nursery purposes.

In order to get an early start on our watershed-planting program, nursery stock, consisting of white and red pine two-year seedlings, was purchased and transplanted in two nursery sites selected for this purpose.

A nursery site was then selected for the purpose of growing trees from seed. This nursery was located in the former town of Enfield, on an area which is now some 80 ft under water. This nursery was used for only two years and produced over 3,000,000 two-year seedlings, which were transplanted to a more permanent nursery site in Belchertown, near the Administration Buildings.

A more simplified method of nursery planting was adopted, in the development of this nursery, than is generally employed in nursery practice.

The area, which had been plowed the previous fall, was thoroughly cultivated and raked over to remove all stones, sod, and other coarse material. The surface of the soil was smoothed over, leveled off, and staked out with string into strips 45 in. wide for seed beds, with 2-foot strips between for paths (see Fig. 1). Some of the soil from the paths was raked into the seed-bed area, in order to raise the beds slightly above the paths, to facilitate good drainage. The seed-bed frames were then constructed by placing eight-inch boards directly on the ground along the sides of the beds. These boards were held firmly in place by 2″ x 2″ stakes about 18″ long, driven into the ground at about 6-foot intervals along the outside of the boards and 1″ x 3″ stakes driven on the inside of the boards opposite the outside stakes. This method eliminated the use of nails and the boards could be used in any lengths without sawing. The seed-bed frames were made in continuous lengths of 100 or 150 feet, depending on the space available, so that 50-foot lengths of snow fence could be used for shade covers, instead of lath frame covers, as the snow fence could easily be rolled back and replaced as required. This eliminated the extra work and expense of building individual, 12-foot, wooden, wire-covered frames

FIG. 1.—PHOTO SHOWING TYPE OF SEED-BED FRAMES AND SNOW-FENCE COVERS USED IN FOREST NURSERY AT QUABBIN RESERVOIR.

and separate lath and wire-covers, which is the usual type of seed-bed frame used in forest nurseries.

The species of tree seed, selected for planting, consisted of white pine, red pine, white spruce, red spruce, Norway spruce, European larch and hemlock.

The white pine and hemlock seeds were treated for "after ripening", so-called, and the seed of the other species was soaked in a normal Semesan solution previous to planting, to destroy the "damping-off" fungus, which might be present in the seed coats. The seed was then allowed to dry partially and was broadcast in the seed beds at the rate of approximately 100 seeds per sq ft. A thin layer of clean, fine, sandy subsoil was then sifted over the seed and the beds were rolled with a medium-weight roller, to press the seed into firm contact with the soil. The subsoil was used to cover the seed, in order to reduce the chances of infecting the beds with the "damping-off" fungus, which is generally present in topsoil. A layer of clean sand was then sifted over the beds about ¼ in. thick and the beds were rolled again. The layer of sand helped to retain the moisture in the soil and prevented the surface of the seed beds from becoming dry and crusted over. This promoted better germination of the seed and produced a greater yield of seedlings.

The beds were then thoroughly sprinkled and covered with the snow fence and strips of burlap. These covers were kept on the beds during the germination period and, as soon as the seedlings were observed breaking through the ground quite generally throughout the beds, the burlap was removed and the snow-fence covers were left in place, to produce half-shade. As soon as the burlap covers had been removed after the germination period, the beds were sprinkled with a normal Semesan solution (1 lb of Semesan to 48 gal of water) at the rate of 5 gal per 35 linear feet of seed bed, to destroy any "damping-off" fungi which might be present in the surface soil. The beds were watched closely and, if any sign of "damping off" began to appear among the seedlings, after the initial spraying, later applications of Semesan solution were made at intervals of several days. The snow-fence covers were left on the beds continuously until about the first of August, when they were rolled back for short periods on sunny days. The time of exposure to full sunlight was gradually increased until, by

the middle of September, the covers were left off entirely, in order to harden off the seedlings for winter. All the species of trees, with the exception of the hemlock, were grown for two years in the seed beds and the snow-fence covers were removed during the first season of growth.

The hemlocks, however, being very slow-growing in the early stages of seedling development and very intolerant to full sunlight exposure, were grown three years in the seed beds and kept entirely covered with snow fence throughout the first two seasons of growth. They were gradually exposed to full light during the third season and even then, during extremely brilliant, hot, sunny days, they were covered to prevent sun scorching.

The seedling beds were kept well weeded and were watered during dry spells. Diseases and insect pests were kept under control by various sprays, applied several times during the growing season.

The beds were prepared for winter by covering them with a light layer of straw, as soon as the ground had frozen, and then placing the snow-fence and burlap covers over them and thoroughly battening them down with lath strips, nailed along the sides and ends of the seed-bed frames.

After the pine and spruce seedlings had been allowed to grow in the seed beds for two years, they were transplanted to another area in the nursery, which had been previously prepared for this purpose. The hemlock seedlings were transplanted after three years in the seed beds.

The trees were allowed to grow for two years in the transplant beds and were then ready for watershed planting.

They were dug up, as soon as the frost was out of the ground in the spring, counted and tied up in bundles of 25 trees each, and "heeled-in" in trenches in the nursery, in readiness for transportation to the planting areas.

Watershed planting was started as early as possible in the spring and continued until the first part of June, or when the new growth on the trees was too far advanced to allow further handling. The trees were sent by truck to the planting areas, were heeled-in in trenches or placed in nearby brooks or water holes, and carried from there in pails to the planting crews.

The planting crews were generally made up of 23 men each—ten two-man planting teams, two men carrying trees to the planters and a foreman. The planting teams consisted of one man digging the holes and the other following behind, planting the trees. It was the foreman's duty to follow along in a zig-zag manner behind the crew, checking the planting to see that it was properly done and that the trees were set solidly in the ground and at the proper spacing.

The planting tool used was the so-called "Harvard Planter", a chisel-type tool with a blade, 6 in. wide and 8 in. long, attached to a straight, cantdog-type handle, 4½ ft long. From our experience, this was found to be a very efficient tool for planting trees, provided it was properly used. When the men had become proficient at both digging and planting, they could average 1,000 trees per day per man.

The manner of using this tool is as follows: The digger holds the "Harvard Planter" in front of him with the blade lengthwise to the planting row and, with a plunging stroke, drives the digger into the ground the full depth of the blade, then forces the handle to the right and then to the left, making a hole in the ground in the shape of an inverted "V", with a narrow opening at the surface of the ground. The planter inserts the roots of the tree into this opening, pushes it down to force the tree roots well down to the bottom of the hole, then lifts the tree up to the proper depth and stamps the ground down with his heel on either side of the tree, to pack the soil firmly around the roots and stem.

A tremendous amount of this work has already been accomplished to date and, so far, we have produced approximately 10,000,000 trees in our nursery and have reforested an area of about 9,000 acres on the Quabbin Reservoir and Ware River watersheds.

This means that some 9,000 acres of once unproductive wasteland are now producing a great watershed forest of commercially valuable timber, to add to our rapidly diminishing supply of this natural resource, as well as to provide the added protection to our reservoir watershed.

BOOK REVIEW

Water Treatment for Industrial and Other Uses. By Eskel Nordell. vii + 526 pp. New York, N. Y.: Reinhold Publishing Corp., 1951. $10.00.

This book forms a comprehensive reference work on the conditioning and treatment of water supplies, primarily for industrial purposes. The presentation of basic principles involved and the solutions to specific problems will be of practical value to executives, consultants, operating personnel and students.

The first four chapters are devoted chiefly to impurities in water supplies and how they can be eliminated or reduced. Chapter 5 concerns the water requirements for industrial uses, and current water-treatment practices in various industries are discussed. The next two chapters describe the problems and practices relating to boiler feed waters and cooling waters. In the remaining 11 chapters, the different processes and equipment used in treating water are covered in detail. An appendix contains 43 tables of conversion factors.

The scope of the book is illustrated by the following list of chapter headings:

1. Industrial Water Supplies.
2. Dissolved Mineral Matter.
3. Dissolved Gases.
4. Turbidity, Sediment, Color, Organic Matter, Tastes, Odors and Microörganisms.
5. Water Requirements.
6. Boiler Feed Waters.
7. Cooling Waters.
8. Aeration.
9. Deaeration.
10. Chemical Feeders.
11. Sedimentation, Coagulation, Settling and Filtration.
12. Iron and Manganese Removal.
13. Zeolite (Sodium Cation-Exchanger) Water-Softening Process.
14. Hydrogen Cation-Exchanger Processes.
15. Demineralization and Distillation.

16. Cold Lime-Soda Water-Softening Processes.
17. Hot Lime-Soda Water-Softening Process.
18. Silica Removal.

The volume contains 126 illustrations, together with numerous tables, as well as the 31-page appendix. A selected list of publications on water-treating materials, processes and equipment is presented in the chapter bibliographies.

GEORGE C. HOUSER

PROCEEDINGS

November 1951 Meeting

Hotel Statler, Boston, Mass.
Thursday, November 15, 1951

President Frederick O. A. Almquist in the Chair.

Secretary Knox announced the election of the following to membership in the Association:

Chester E. Bradley, Superintendent, Water Department, Swampscott, Mass.; John J. Cotter, Supervisor of Plant and Maintenance, Connecticut State Hospital, Middletown, Conn.; Thomas F. Culliney, Superintendent, Water Department, Cohasset, Mass.; Fred S. Daniels, Utilities Operator, University of New Hampshire, Durham, N. H.; James P. Donovan, Superintendent, Water Department, Quincy, Mass.; W. Elwin Dunn, Clerk and Treasurer, Adams Fire District, Adams, Mass.; Alfred F. Ferullo, Chemist, Metcalf & Eddy, Boston, Mass.; Carl M. Jacobson, Assistant Town Engineer, Stoneham, Mass.; Carl G. Johanson, Superintendent, Water Department, Littleton, Mass.; Harold D. Kilgore, Jr., Chief Sanitary Engineer, Anderson-Nichols & Co., Boston, Mass.; Lester H. Longton, Jr., Civil Engineer, R. H. White Construction Co., Worcester, Mass.; Francis J. McLaughlin, Superintendent, Water Department, Holbrook, Mass.; Joseph A. Sherman, Manager, Chatham Water Co., Chatham, Mass.; Russell F. Tennant, Superintendent of Public Works, Attleboro, Mass.; Norman M. Winch, Public Health Engineer, Portland, Me.; John P. Wold, Sanitary Engineer, U. S. Public Health Service, Boston, Mass.

Junior Member:

Francis J. Murphy, Civil Engineer, Fay, Spofford & Thorndike, Boston, Mass.

Corporate Members:

Board of Water Commissioners, Swampscott, Mass.; Board of Public Works, Reading, Mass.

Associate Members:

Stephen B. Church Co., Seymour, Conn.; General Electric Co., Boston, Mass.

A paper on "Sanitary Supervision of Maine Water Supplies" was read by Howard H. Potter, Maine Public Utilities Commission, Augusta, Me.

A paper on "Experiences in Operation of a Small Water Department" was read by Fred E. Colby, Superintendent, Water Department, Bridgewater, Mass.

A paper on "Design and Operation of an Automatic Filter" was read by Wilfred C. Gilbert, Assistant Sanitary Engineer, State Department of Health, Burlington. Vt.

December 1951 Meeting

Hotel Statler, Boston, Mass.

Thursday, December 20, 1951

President Frederick O. A. Almquist in the Chair.

Secretary Knox announced the election of the following to membership in the Association:

Alfred A. Abare, Superintendent, Water Department, Palmer, Mass.; August Ammann, Water Commissioner, Palmer, Mass.; Kenneth J. Carl, Engineer, National Board of Fire Underwriters, Baldwin, N. Y.; John J. Donahue, Clerk, Water Department, Palmer, Mass.; William R. Colton, Sales Representative, Warren Pipe Co., Boston, Mass.

Reinstated:

Edward M. Cahalan, Pawtucket, R. I.; Irving B. Crosby, Boston, Mass.

An address entitled "Washington Report" was presented by the Honorable Leverett Saltonstall, U. S. Senator from Massachusetts.

A paper on "New Gas Transmission Lines in Relation to Massachusetts Water Supplies" was read by Ralph M. Soule, Associate Sanitary Engineer, Massachusetts Department of Public Health, Boston, Mass.

A paper on "Recent Improvements to the Water-Supply Works of Mansfield, Massachusetts" was read by L. M. Pittendreigh, Engineer, Whitman & Howard, Boston, Mass.

JANUARY 1952 MEETING
HOTEL STATLER, BOSTON, MASS.
THURSDAY, JANUARY 17, 1952

President Frederick O. A. Almquist in the Chair.

Secretary Knox announced the election of the following to membership in the Association:

Oscar Cianca, Engineer, R. Zoppo Co., Dedham, Mass.; Ezra S. Johnson, Superintendent, Lunenburg Water District, Lunenburg, Mass.; George K. Allen, Assistant Superintendent, Water Department, Hopedale, Mass.; Mrs. Lucille W. Hitchcock, President, Cambridge Water Co., Cambridge, N. Y.

Reinstated:

Robert A. Harrington, Superintendent, Water Department, Greenfield, Mass.

Associate Member Reinstated:

Perrin, Seamans & Co., Inc., Boston, Mass.

President Almquist announced the death of one of the oldest members of the Association, Frank L. Northrop, who became a member in June, 1893, and died January 15, 1952.

Mark Croker, Chairman of the Commitee on Legislation, reported on House Bill 496, which was before the Massachusetts General Court and was scheduled for hearing by the Committee on Municipal Finance on January 30. This bill provided for the borrowing of funds for the purpose of lining water mains, 6 to 16 in. in diameter. Upon motion duly made and seconded, it was VOTED that the Association be recorded favorably on this legislation at the hearing on January 30.

A paper on "Significance of Radioactivity to Water-Works Superintendents" was read by Rolf Eliassen, Professor of Sanitary Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

A paper on "Equipment and Records of the Winchester Water and Sewer Departments" was read by James D. Halwartz, Superintendent of the Water and Sewer Departments, Winchester, Mass.

A paper on "Bridge Crossings" was read by George Howland, III, Engineer, Metcalf & Eddy, Boston, Mass.

COMMITTEE TO REPORT ON DEVELOPMENTS IN OUR KNOWLEDGE OF CORROSION AND ITS MITIGATION

Third Report

To the President and Members of the New England Water Works Association:

Following the annual meeting of the Association in September, 1950, the membership of the Committee to Report on Developments in Our Knowledge of Corrosion and Its Mitigation was completely revamped. The present committee membership believes that the procedure followed in previous reports, of surveying the advances in selected areas of the broad field of corrosion as new and significant knowledge becomes available, is a good one and should be continued.

However, the problems associated with the functioning of a committee that is entirely new in its personnel have prevented the organization of such a report for this year. Instead, the committee has chosen to report a cross-section of recent developments in connection with the corrosion problem, taken largely from symposia on "Corrosion by Water" and "The Effect of Ordinary Constituents on Corrosion by Water," conducted by the Division of Water, Sewage and Sanitation Chemistry of the American Chemical Society at its 75th Anniversary Meeting, September 3-8, 1951.

Three main topics are covered in this report: (1) Fundamentals of Corrosion, (2) Effects of Water Quality, Temperature and Other Variables on Corrosion and (3) Mitigation of Corrosion.

Fundamentals of Corrosion

Recent work on corrosion fundamentals has had as its point of departure the electrochemical theory of corrosion, discussed in the First Report of this Committee (see N.E.W.W.A. Journal for December, 1949). Briefly, this theory proposes that, in general, corrosion proceeds as a result of difference in electrochemical potential between various areas of the metal surfaces, brought about by differences in composition, grain size or orientation, phase boundaries, strains or any other factors causing non-uniformity of the metal surface, either on a macroscopic or microscopic scale. At those areas of the surface that are relatively more positively charged (anodic areas), metal is

dissolved as ions and may then undergo a variety of reactions, depending on the properties of the water in contact with the metal. At the more negative sites (cathodic areas) reduction of hydrogen ions to elemental hydrogen, adsorbed on the surface of the metal, occurs. In order for continuous corrosion to proceed, the adsorbed hydrogen which "polarizes" the metal surface must be removed, either by forming hydrogen gas or by reaction with some other material in the water (depolarization). Any one of the steps in this rather complicated process may, under appropriate conditions, be the factor limiting the rate at which corrosion proceeds. Also, significant inhibition of corrosion may be produced if any one of the steps can be sufficiently reduced in rate.

Most commonly, with iron or steel surfaces, the step controlling the rate of corrosion is the depolarization of cathodic areas by removal of adsorbed hydrogen. Normally, in the pH range 4 to 10 (at 72°F.; 4.5 to 8 at 105° F.), the depolarization is accomplished by reaction of the adsorbed hydrogen with dissolved oxygen and the rate of corrosion is determined by the rate of diffusion of oxygen to the cathodic areas. Under these conditions the accessibility of oxygen to the surface is a function both of the concentration of dissolved oxygen and of the rate of flow of water past the surface. On the other hand, pH has little influence, because it does not affect the oxygen diffusion rate, and, for the same reason, the nature of the metallic surface has little effect on the rate of corrosion; *i.e.* iron or low-alloy steels corrode at essentially the same rates under these conditions. Moreover, rates of corrosion have been found to be the same in this region even when the surface is partially covered.

The effectiveness of coatings for inhibition of corrosion under these conditions, which are the most significant ones for water supplies, is determined by the extent to which they provide a barrier opposing the diffusion of oxygen to the metal surface. However, inhibition can also be obtained through the adsorption of some material other than hydrogen on the cathodic areas, to provide a permanent or semi-permanent polarization of these areas.

It has been noted that oxygen itself may give a polarization film of this type, so that at very high oxygen concentrations (about 23 ppm in soft waters) corrosion rates go through a maximum and then

decrease, as further increases in dissolved oxygen lead to greater polarization of cathodic surfaces.

Effects of Water Quality and Temperature

Dissolved Ions. Apart from specific effects, the presence of dissolved ions in water tends to increase the rate of corrosion, by lowering the resistance of the solution and thus enabling electrochemical effects to operate over greater distances. Specific effects tending to increase corrosion are found with oxidizing substances, such as Fe^{+++}, that can act as depolarizers in place of dissolved oxygen. Under special conditions, discussed in later sections, $SO_4^{=}$ and Cl^{-} ions may also act to accelerate corrosion or to hinder its inhibition.

The inhibiting effects of Ca^{++}, Mg^{++} and $CO_3^{=}$ ions on corrosion, when sufficient concentrations are present to form coatings of $CaCO_3$ or of other insoluble compounds, is well known. Evidence is now accumulating that the primary deposition of $CaCO_3$ is on cathodic areas, thus hindering or preventing cathodic depolarization.

Temperature. Increase in temperature appears to affect the rate of corrosion in many instances, primarily by increasing the rate of diffusion of oxygen to cathodic areas. In closed systems with pure waters the temperature coëfficient of corrosion is reported to be about 3% per degree centigrade, fairly close to the temperature coëfficient for oxygen diffusion. In open systems this increase in rate at higher temperatures is modified by the decreasing solubility of oxygen and under equilibrium conditions a maximum rate of corrosion may occur at higher temperatures.

The effect of temperature on the electrode reactions is also of some importance. A rise in temperature increases the ease of depolarization of cathodic areas and therefore tends to accelerate corrosion. Temperature differences in various parts of the system may also lead to an increase of electrochemical potential between anodic and cathodic areas and thus to a greater corrosion rate.

Other observed temperature effects on corrosion are due to changes in the solubility of materials forming insoluble coatings on cathodic areas or to changes in the physical character of the deposits formed. For example, a maximum in the corrosion rate of zinc in pure water at about 160° F. has been found and correlated with a change in the

character of the solid zinc corrosion product from granular to gelatinous.

The influence of temperature must also be considered in the addition of corrosion inhibitors to water, for the nature and extent of attachment of inhibitors to the metal surface, which partly determine their effectiveness, are a function of temperature.

Velocity. The rate of flow of water has no direct effect on corrosion, unless it becomes high enough to cause erosion of the metal surfaces or of protective films. Through its indirect effects, increased flow rate may either accelerate or depress corrosion, the possible influences being so numerous that prediction is difficult for any specific application. Motion may tend to increase corrosion by increasing the supply of oxygen or other corrosives, by removing corrosion products more rapidly or by setting up zones of turbulence that lead to local attack. Conversely, it may decrease corrosion by making conditions more uniform, so that local attack is prevented, by aiding in the more rapid or more uniform development of protective coatings, or by increasing the rate of supply of inhibitors to the metal surface. Usually the former factors are more important, but no general rules can be drawn.

Bacterial Action. Various forms of bacteria, especially the iron and sulfur bacteria and sulfate-reducing organisms, have been found to lead to acceleration of corrosion. The growth of iron bacteria on pipe walls enhances electrochemical action, the metal surface underneath the tubercles becoming anodic with respect to surrounding areas. Sulfate-reducing bacteria have been shown especially important in the external corrosion of iron and steel pipe, especially on waterlogged land. Their activity in reducing sulfate to sulfide is accompanied by efficient depolarization of cathodic areas, the net reaction being reduction of the sulfate by the adsorbed hydrogen. If the water is completely anaerobic, the rate of this process is slow, but if there are aerobic areas or periods, corrosion from this source may be very severe. The sulfur bacteria, especially *thiobacilli,* operating under aerobic conditions, bring about a series of reactions ending in the oxidation of sulfur to sulfuric acid. This may lead to localized acid corrosion.

Mitigation of Corrosion

Polyphosphate Inhibition. Practical experience in the use of polyphosphates was discussed in the last year's report of this committee (N.E.W.W.A. Journal, December, 1950). Recent studies have shown that the action of polyphosphates results from film formation on cathodic areas that increases cathodic polarization. These tests also showed that the inhibitory effect was determined by the rate of supply of polyphosphate to the cathodic surfaces, that about 10 hours are required to build up a satisfactory film, and that the weight of protective film amounts to about 30-40 milligrams per square foot of metal surface.

Other studies on polyphosphates have shown that the presence of dissolved oxygen is necessary for appreciable inhibitory action. It is reasoned from this that the function of the polyphosphate is to render the cathodic surface suitable for a polarizing adsorption of oxygen. In line with this, it is found that chloride ions, which compete with oxygen with respect to cathodic adsorption and tend to depolarize these areas, lessen the effectiveness of polyphosphates as corrosion inhibitors.

Silicate Inhibition. The protective action of silicates is reported to be associated with the formation of thin, self-healing films of amorphous silica on the metal surface that do not increase in thickness with continuous feeding. Consequently, the mechanism of the action is presumably not the deposition of layers of insoluble silicates.

Recent studies have indicated that in order for the silicate to be removed from solution to form a protective film, some solid corrosion product must be present on the surface. This was found to be particularly true for galvanized or brass pipe, the conclusion being that a film of silica is efficiently adsorbed by the zinc hydroxide corrosion product. Ferric hydroxide does not remove silica from water as effectively as zinc hydroxide and the indications are that the mechanism of removal may be different in this case.

Electrochemical Protection. Protection of a given metal surface against corrosion may be achieved by making it the cathode in an electrochemical system. This may be done, as in galvanizing, by coating iron or steel with the more active metal, zinc, so that the

latter is anodic to the iron and is selectively oxidized. Or, as in some methods for cathodic protection, the more active metal may be suspended in the water separately, appropriate connection to the iron surface being made. In other cathodic methods non-reacting anodes are used, but an external electrical potential is imposed, so as to keep the iron or other metal surface negatively charged.

Recently the important observations have been made that under certain conditions the polarity of zinc with respect to iron may be reversed, so that the iron becomes anodic and acceleration rather than retardation of corrosion results. These findings may account for some reported rapid failures of galvanized tanks or piping and for occasional difficulties with cathodic protection using zinc rods.

Changes in the relative polarity of zinc with respect to iron are particularly significant for hot-water systems—temperatures of 140° F. and above—and their extents and magnitudes have been related to the composition of the water. It has been found that sulfate ions especially, calcium ions and silica less strongly, and chloride ions to some extent, cause iron to become less cathodic toward zinc and hence decrease the efficiency of galvanic protection. On the other hand, bicarbonate ions and especially nitrate ions tend to increase the cathodic behavior of iron when coupled to zinc.

Respectfully submitted,

(Signed) J. Carrell Morris, *Chairman*
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November 15, 1951

C302—51T

American Water Works Association

Tentative

STANDARD SPECIFICATIONS

for

REINFORCED CONCRETE WATER PIPE—NONCYLINDER TYPE, NOT PRESTRESSED

These "Tentative Standard Specifications for Reinforced Concrete Water Pipe—Noncylinder Type, Not Prestressed" are based upon the best known experience and are intended for use under normal conditions. They are not designed for unqualified use under all conditions and must be reviewed by the engineer responsible for the construction and modified as necessary to meet specific conditions pertaining to each individual installation.

Approved by the Board of Directors of the A.W.W.A. as "Tentative Standard"
September 4, 1951

Third Printing, March 1952

AMERICAN WATER WORKS ASSOCIATION
Incorporated
521 Fifth Avenue, New York 17, N.Y.

Prepared by

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NOTE: All references to standards of the A.W.W.A. or other technical societies or of the federal government within these specifications are to the latest revisions, including amendments, of the documents involved. The revision letters on federal standards and the date key on those of A.W.W.A. and other technical societies have been omitted to avoid early obsolescence of such references.

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Tentative Specifications for

Reinforced Concrete Water Pipe—Noncylinder Type, Not Prestressed

Section 1—General

Sec. 1.1—Scope

These specifications cover the manufacture of reinforced concrete pressure pipe, without steel cylinder and not prestressed, in sizes from 12 in. to 96 in. inclusive, designed for service where the maximum design head shall not exceed 100 ft. and for such external loading conditions as may be designated by the purchaser. This type of pipe has been extensively used on low-head transmission work, reservoir connections and lines not subject to possibility of higher heads or shock but has been little used and is not recommended for other than very special conditions in distribution system work. The specifications do not include delivery, laying, field testing or sterilization of the pipe.

Sec. 1.2—Definitions

In these specifications the following definitions will apply:

1.2.1. *Purchaser.* The word "purchaser" shall mean a person, firm, corporation or governmental subdivision entering into a contract or agreement to purchase any materials, or have any work performed, according to these specifications.

1.2.2. *Contractor.* The word "contractor" shall mean the person, firm or corporation executing the contract or agreement with the purchaser to furnish any materials or perform any work according to these specifications.

1.2.3. *Manufacturer.* The word "manufacturer" shall mean the person, firm or corporation who actually manufactures the pipe, acting either directly as the contractor or as a subcontractor. If the manufacturer is acting as a subcontractor under the contractor, the obligations of the manufacturer under these specifications shall be considered as obligations of the contractor, and the contractor shall be responsible for their performance.

1.2.4. *Engineer.* The word "engineer" shall mean the engineer employed by the purchaser and acting as the purchaser's representative; the purchaser himself, acting as his own engineer; and their respective assistants and inspectors.

1.2.5. *A.S.T.M.* The term "A.S.T.M." shall mean the American Society for Testing Materials. When specific A.S.T.M. specifications are cited, the designation shall be construed to refer to any subsequent revision under the same specification number, or superseding specifications under a new number, except as to provisions in the revised specifications which clearly are inapplicable.

1.2.6. *Approved.* The term "approved" shall mean having received the approval of the engineer.

1.2.7. *Internal Pressures.* The term "internal pressures" shall mean hydrostatic pressures imposed on and applied to the interior of the pipe by the design head specified by the purchaser.

Internal pressures shall be expressed in pounds per square inch.

1.2.8. *External Loads.* The term "external loads" shall mean all superimposed live and dead loads applied to the pipe after installation and shall be independent of any and all hydrostatic pressures within the pipe. External loads shall be expressed in pounds per linear foot of pipe.

Sec. 1.3—Essential Requirements

The pipe shall have the following principal features: a reinforcing cage or cages of steel rods, bars, wire or fabric; a wall of dense concrete covering the reinforcing cage or cages inside and out; and approved type of joint with a preformed gasket or gaskets of rubber so designed that the joint will be watertight under all normal conditions of service.

Sec. 1.4—Plans and Data Furnished by Purchaser

The purchaser shall designate the total head or resulting internal pressure for which the pipe shall be designed. If the pipe is to be used under conditions where the superimposed external loads will be a determining factor in the design of the pipe, the purchaser also shall designate the external load or details of external loading conditions for which the pipe shall be designed. If the contractor is required to vary the design of the pipe for specific conditions in accordance with its location in a pipe line, the purchaser shall furnish to the contractor plans and profiles of the pipe line showing: alignment and grades; the location of all outlets, connections and special appurtenances; the design head and external loads or the required cross-sectional area of effective circumferential reinforcement per foot of pipe wall for each portion of the pipeline; and such special details as are necessary for the manufacture of the pipe and fittings in accordance with these specifications and with the specific requirements of the work for which the particular pipe is made.

Sec. 1.5—Supplementary Details Specified by Purchaser

When purchasing pipe under these specifications, it will be necessary for the purchaser to make supplementary statements specifying: the manner of storage and delivery if these are required of the contractor or manufacturer; and the type of specials and fittings to be furnished.

Sec. 1.6—Data Submitted by Contractor

1.6.1. Drawings and schedules showing full details of reinforcement, concrete and joint dimensions for the pipe shall be furnished by the contractor. All drawings and schedules shall be submitted for approval in quadruplicate, and one copy shall be returned to the contractor after approval. No pipe shall be maufactured until the drawings have been approved.

1.6.2. If specifically required, the data submitted by the contractor shall include a tabulated layout schedule, with reference to the stationing and grade line shown on the contract drawings. The schedule shall show pressure and external loading zones, each of which shall be designated by the design head and external load applicable therein, and the point of change from one zone to the next shall be clearly indicated by station number. The diameter of pipe, the design head, the external load, and the thickness of pipe wall and area of steel (per linear foot of pipe) in the reinforcing rods or wire shall be listed

for each portion of pipe line for which the design head or the equivalent internal pressure and the external load is fixed by the purchaser.

Sec. 1.7—Marking

Each special and each length of straight pipe shall have plainly marked on the bell end the identification marks specified by the purchaser. These shall include, as specified, either the head and external load for which the pipe or special is designed or the area of effective circumferential reinforcement per foot of pipe wall. Special marks of identification, sufficient to show the proper location of the pipe or special in the line by reference to layout drawings and schedules specified under Sec. 1.6 of these specifications, shall be placed on the pipe if required. All beveled pipe shall be marked with the amount of the bevel. If elliptical reinforcing is used, the minor axis of the reinforcing shall be designated on the interior surface of the bell end of the pipe.

Sec. 1.8—Inspection

1.8.1. The purchaser and his representatives shall have access to the work wherever it is in preparation or progress, and the contractor shall provide proper facilities for access and for inspection.

1.8.2. Inspection by the purchaser or his representatives, or failure of the purchaser or his representatives to provide inspection, shall not relieve the contractor of his responsibility to furnish materials and to perform work in accordance with these specifications.

1.8.3. Material, fabricated parts and pipe which are discovered to be defective or which do not conform to the requirements of these specifications, will be subject to rejection at any time prior to final acceptance of the pipe. Rejected material and pipe shall promptly be removed from the site of the work.

Sec. 1.9—Material and Workmanship

All material furnished by the contractor shall be new and of the quality specified. All work shall be done in a thorough, workmanlike manner by mechanics skilled in their various trades.

Sec. 1.10—Tests

1.10.1. The contractor shall furnish, in advance of manufacture of reinforcing cages, mill test reports on each heat from which the steel is rolled, if required.

1.10.2. The contractor shall provide test specimens cut on the job from each shipment of steel for reinforcing as directed by the engineer.

1.10.3. Welds in reinforcing rods or bars shall be tested as specified under Sec. 3.5.

1.10.4. Frequent samples of mixed concrete shall be taken for making up compression test cylinders as specified under Sec. 3.6.

1.10.5. If required by the engineer, the contractor shall submit test results showing the chemical and physical properties of rubber used in the gaskets.

1.10.6. The expense of the required mill tests of materials, and of testing the welds in the reinforcing shall be borne by the contractor. All other tests shall be made by representatives of the purchaser at the purchaser's expense, except as otherwise specifically provided.

Section 2—Material Specifications

Sec. 2.1—Cement

2.1.1. Cement for concrete work shall conform to the "Standard Specifications for Portland Cement, Type I or Type II," (A.S.T.M. Designation C150). Sampling and testing shall conform to the individual A.S.T.M. specifications designated therein.

2.1.2. Satisfactory facilities shall be provided for identifying, inspecting and sampling cement at the mill, the warehouse and the site of the work. The purchaser shall have the right to inspect the cement and obtain samples for testing at any of these points.

2.1.3. Cement shall be stored in a weather-tight, dry, well ventilated structure approved by the engineer.

2.1.4. Cement salvaged by cleaning cement sacks, mechanically or otherwise, shall not be used in the work. Cement containing lumps will be rejected and shall immediately be removed from the site of the work.

2.1.5. If the temperature of the cement exceeds 150°F., it shall be stored until cooled to that temperature.

Sec. 2.2—Fine Aggregate

2.2.1. Fine aggregate for concrete and mortar shall consist of clean, hard, durable and uncoated particles of natural sand or sand prepared from the product obtained by crushing stone, gravel or other inert materials having similar qualities. The type of material shall be subject to the approval of the engineer. At the time of use the fine aggregate shall be entirely free of frozen material.

2.2.2. Fine aggregate shall be free from organic impurities to the extent that, when subjected to the color test for organic impurities, it shall produce a color in the sodium hydroxide solution not darker than that of Fig. 2 in the "Standard Method of Test for Organic Impurities in Sands for Concrete" (A.S.T.M. Designation C40).

2.2.3. Fine aggregate shall be of such quality that mortar composed of it, when tested by the "Standard Method of Test for Structural Strength of Fine Aggregate Using Constant Water-Cement Ratio Mortar" (A.S.T.M. Designation C87), shall have a compressive strength equal to that of similar specimens—of the same proportions and composed of the same cement and Ottawa sand—graded as specified in the "Method of Test for Compressive Strength of Hydraulic-Cement Mortars" (A.S.T.M. Designation C109).

TABLE 1

Gradation Requirements for Fine Aggregate

Sieve Size	Total Passing, by Weight *per cent*
⅜ in.	100
No. 4	95–100
No. 8	65–98
No. 16	45–80
No. 30	20–70
No. 50	5–50
No. 100	2–10
No. 200	0–5

2.2.4. Fine aggregate shall be well graded from coarse to fine and, when tested by means of laboratory sieves in accordance with the "Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates" (A.S.T.M. Designation C136), shall conform to the gradation requirements in Table 1.

The gradation requirements given in Table 1 represent the extreme limits for determining the suitability of fine aggregate under these specifications.

To maintain uniformity of gradation for aggregate from any given source, a fineness modulus determination shall be made upon representative samples from that source. Thereafter, the fineness modulus of all shipments therefrom shall not vary more than ± 0.20 from the fineness modulus of the representative sample.

Sec. 2.3—Coarse Aggregate

2.3.1. Course aggregate for concrete shall consist of hard, durable particles of crushed stone or crushed or uncrushed gravel conforming to the requirements and tests given in paragraphs 2.3.2 through 2.3.5.

2.3.2. Coarse aggregate shall be well graded from coarse to fine. The maximum size and gradation shall be subject to the approval of the engineer and shall be such that the concrete can be readily placed inside the mold, by the particular method used in placing it, to provide a solid, compact, homogeneous wall with a smooth surface. Tests for gradation of coarse aggregate shall be in accordance with the "Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregate" (A.S.T.M. Designation C136).

2.3.3. Deleterious substances in coarse aggregate shall not exceed the amounts given in Table 2 as determined by sampling and testing procedures listed in the "Standard Specifications for Concrete Aggregates" (A.S.T.M. Designation C33).

2.3.4. Thin and elongated pieces, the maximum dimension of which exceeds five times the minimum, shall not be in excess of 10 per cent of the coarse aggregate by weight.

2.3.5. The coarse aggregate, when subjected to five alternations of the sodium sulfate test in accordance with the "Tentative Method of Test for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate" (A.S.T.M. Designation C88), shall have a corrected loss not in excess of 12 per cent unless specifically permitted by the engineer.

Sec. 2.4—Samples of Concrete Aggregates

At least four weeks prior to mixing concrete, the contractor, if required, shall deliver in suitable containers, for preliminary approval, samples of not less than 1 cu.ft. each of fine aggregate and coarse aggregate. All samples shall be plainly labeled to indicate the source of the material, the date and the name of the collector. Methods of sampling aggregates shall be in accordance with the "Tentative Methods of Sampling Stone, Slag Gravel, Sand and Stone Block for Use as Highway Materials" (A.S.T.M. Designation D75).

TABLE 2

Permissible Amounts of Deleterious Substances in Course Aggregate

Material	Max. Weight Limit *per cent*
Soft particles	4.00
Coal and lignite	0.50
Clay lumps	0.25
Material finer than 200 sieve	1.00
Combined total of above items	5.00

Sec. 2.5—Water

Water used for concrete and for curing pipe shall be clean and free from oil, acid, strong alkalies or vegetable matter, and the source shall be approved by the engineer.

Sec. 2.6—Steel for Reinforcement

2.6.1. Rods or bars for reinforcement of concrete shall conform to the "Stand-

ard Specifications for Billet-Steel Bars for Concrete Reinforcement, Structural Grade" (A.S.T.M. Designation A15). Steel wire for reinforcement of concrete shall conform to the "Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement" (A.S.T.M. Designation A82). Wire fabric for reinforcement of concrete shall conform to the "Standard Specifications for Welded Steel Wire Fabric for Concrete Reinforcement" (A.S.T.M. Designation A185).

2.6.2. Wire fabric reinforcement for mortar coating of fittings shall conform to the "Standard Specifications for Welded Steel Wire Fabric for Concrete Reinforcement" (A.S.T.M. Designation A185).

2.6.3. Steel rod or bar reinforcement for concrete for fittings shall conform to "Standard Specifications for Billet-Steel Bars for Concrete Reinforcement, Structural Grade" (A.S.T.M. Designation A15).

Sec. 2.7—Steel for Joint Rings

In joint designs incorporating metal joint rings, the following shall apply:

2.7.1. Steel strips for bell rings less than ¼ in. thick shall conform to "Tentative Specifications for Hot-Rolled Strips of Structural Quality" (A.S.T.M. Designation A303).

2.7.2. Steel plate for bell rings ¼ in. or more in thickness shall conform to the "Tentative Specifications for Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality" (A.S.T.M. Designation A283).

2.7.3. Special shapes for spigot joint rings shall conform to the "Standard Specifications for Boiler Rivet Steel and Rivets (A.S.T.M. Designation A31), except that paragraph 7 (b) shall be waived, or to the "Tentative Specifications for Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality" (A.S.T.M. Designation A283).

Sec. 2.8—Steel Castings for Fittings

Steel castings for fittings shall conform to the "Tentative Specifications for Mild to Medium Strength Carbon-Steel Castings for General Application, Grade 70–36, Normalized" (A.S.T.M. Designation A27).

Sec. 2.9—Steel Sheets for Specials and Fittings

Steel sheets for specials and fittings shall conform to the "Tentative Specifications for Heavy Gage Structural Quality Flat Hot-Rolled Carbon Steel, Open Hearth, Grade B" (A.S.T.M. Designation A245).

Sec. 2.10—Steel Plates for Specials and Fittings

Steel plates for specials and fittings shall conform to the "Tentative Specifications for Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality, Grade B or C" (A.S.T.M. Designation A283).

Section 3—Fabrication of Pipe

Sec. 3.1—General Requirements

3.1.1. In general pipe shall have a minimum length of 8 ft. except for bends, reducers, closure pieces and other special fittings which may be made in shorter lengths. The maximum lengths shall be as follows:

Size—*in.*	Max. Length—*ft.*
12–15 (inclusive)	8
16–21 (inclusive)	12
24 and larger	16

3.1.2. Pipe shall be round and true and shall have smooth and dense finished surfaces. The mean internal diameter of any portion of each section of pipe shall not fall short of the nominal diameter or size specified by more than 1.0 per cent if the pipe is 48 in. or smaller, or by more than 0.75 per cent if the pipe is 54 in. or larger. The wall thickness shall not have a minus variation of more than 5 per cent from the nominal thickness shown in Table 3.

3.1.3. The minimum wall thickness, the minimum and maximum center-to-center spacing of circumferential reinforcement and the number of circumferential reinforcing cages for each size of centrifugal and vertically cast pipe shall be as shown in Table 3.

Sec. 3.2—Design of Steel Reinforcement

The reinforcement of the pipe shall consist of one or more cages of welded steel hoops, helically wound steel rods, wire, or welded fabric properly spaced and supported with longitudinal reinforcing. Each cage shall have a minimum longitudinal reinforcement equivalent to $\frac{1}{2}$-in. round steel rods at a maximum spacing of 30 in. center-to-center, except that no cage shall have less than six rods of at least $\frac{1}{4}$-in. diameter. The combined cross-sectional area of circumferential steel in the reinforcement cage or cages shall be such that the steel will not be stressed in excess of 12,500 psi. when the pipe is subjected to an internal pressure equivalent to the hydrostatic head or pressure

TABLE 3

Requirements for Pipe of Various Sizes

Pipe id. *in.*	6,000-psi. Centrifugal Concrete		4,500-psi. Poured Concrete		Circumf. Reinf. Spacing *in.*	
	Min. Pipe Wall Thickness *in.*	Min. No. of Cages	Nominal Pipe Wall Thickness *in.*	Min. No. of Cages	Min.	Max.
12	2	1	—	—	1¼	4
15	2	1	—	—	1¼	4
16	2⅛	1	—	—	1¼	4
18	2¼	1	—	—	1¼	4
20	2⅜	1	—	—	1¼	4
21	2⅜	1	—	—	1¼	4
24	2½	1	3½	1	1¼	4
27	2⅝	1	3½	1	1½	4
30	2¾	1	3½	1	1½	4
33	2⅞	1	4	2	1¼	4
36	3	1	4	2	1¼	4
42	3½	2	4½	2	1¾	5
48	4	2	5	2	1¾	5
54	4½	2	5½	2	1¾	5
60	5	2	6	2	1¾	5
66	5½	2	6½	2	2¼	6
72	6	2	7	2	2¼	6
84	7	2	8	2	2¼	6
96	8	2	8½	2	2¼	6

fixed by the purchaser, with no allowance for the tensile strength of the concrete. Reinforcement for pipe for use in heavy traffic or deep trenching conditions in which the external loading is a determining factor in the design shall be designed for combined internal and external loading designated by the purchaser. The details of the design and reinforcement shall be submitted for approval by the purchaser. The circumferential steel for all sizes of pipe shall be at least the equivalent of the amount shown in Table 1 for 4,500-psi. concrete of A.S.T.M. Specification C76 for "Standard-Strength Reinforced Concrete of Culvert Pipe."

Sec. 3.3—Joints

The contractor shall submit with his bid details of the joints to be furnished. The joints shall be of the round rubber gasket type using either a bell-and-spigot joint design or a double spigot and sleeve joint design of concrete or steel. In either type, the joints shall be so designed that when the pipe is laid and the joint completed, the gasket will be enclosed on all four surfaces. The joints shall be so designed and fabricated that when the pipe is laid, it will be self-centering and the gasket or gaskets shall not be required to support the weight of the pipe, but shall keep the joint tight under all normal conditions of service, including expansion, contraction and normal earth settlement. The bell and spigot surfaces of the pipe shall be accurately formed to provide closely fitting joints. The tolerance between the theoretical diameters and the actual diameters of the contact surfaces shall be such that the average clearance shall not exceed $\frac{1}{16}$ in. If the joints are fabricated employing steel bell-and-spigot joint rings or a steel sleeve, each ring shall be formed by one or more pieces of steel, which are butt-welded together either by a resistance weld or by hand electric arc weld. After welding the ring shall be smoothed by grinding the rough surfaces of the weld flush with the adjacent surfaces. The rings shall be expanded by a press beyond their elastic limits so that they are accurately shaped. They shall be checked for size and shape on accurate templates before being incorporated in the pipe. The minimum thickness of the completed bell or spigot ring shall be $\frac{3}{16}$ in. The ring shall conform to the details submitted by the manufacturer and approved by the engineer. The contact surfaces shall be smooth to prevent cutting of the rubber gasket during installation. The portions of the joint ring which will be exposed after the pipe is cast shall be protected from corrosion by an approved metallic coating with a minimum thickness of 0.002 in. applied by an approved method. When specifically permitted, an approved nonmetallic coating may be used.

Sec. 3.4—Rubber Gaskets

3.4.1 The joint shall be sealed with a continuous-ring gasket made of a special composition rubber of such size and cross section as to fill completely the recess provided for it. The gasket shall be the sole element depended upon to make the joint watertight and shall have smooth surfaces free from pits blisters, porosity and other imperfections. The rubber compound shall contain not less than 50 per cent by volume of first grade natural crude or first grade synthetic rubber. The remainder of the compound shall consist of pulverized fillers free from rubber substitutes, reclaimed rubber and deleterious substances. The compound

shall meet the following physical requirements when tested in accordance with appropriate sections of "Methods of Physical Tests and Chemical Analyses for Rubber Goods" (Federal Specification ZZ–R–601):

Tensile strength. The tensile strength of the compound shall be at least 2,700 psi. for natural rubber gaskets and 1,700 psi. for synthetic rubber gaskets.

Elongation at rupture. Two-in. gage marks shall stretch to not less than 9 in. at rupture.

Specific gravity. The specific gravity shall be between 1.15 and 1.25.

Cold flow test. The proportion of cold flow—computed as 100 times the change in thickness divided by the original thickness—shall not exceed 12 when tested by subjecting a disk of the material, $\frac{1}{4}$ in. thick by $\frac{3}{4}$-in diameter, to a pressure of 600 psi. using a spring-pressure device placed in an air oven at a temperature of 158°F. for 24 hours.

Tensile strength after aging. The tensile strength of the compound, after being subjected to an accelerated aging test for 96 hours in air at 158°F., shall not be less than 80 per cent of the tensile strength before aging. The test shall be that described in "Methods for Testing Rubber Goods" (Federal Specication ZZ–R–601, Sec. 2, Par. 14).

3.4.2 The contractor shall submit for approval details of the shape and size of the gaskets he proposes to furnish. If required by the engineer, the contractor shall also submit test results showing the chemical and physical properties of the materials used in the manufacture of the gaskets.

Sec. 3.5—Fabrication of Reinforcement Cage

The steel reinforcement cage or cages shall be made of continuous or welded steel rods or wire wound in helical form, individual bars shaped and butt- or lap-welded into circular rings, or welded fabric shaped and butt- or lap-welded into cages, as approved by the purchaser. Each circumferential butt weld in the rods or bars shall be subjected to a test stress of 25,000 psi. before being assembled in the cage. When welded fabric is used, each welded splice or intersection shall develop a tensile strength not less than the minimum strength required for the reinforcement by the applicable specifications cited in Section 2.6. The circumferential rods, bars or fabric in the cage shall be accurately spaced and shall be rigidly assembled by means of longitudinal rods securely attached to them in approved manner. Each cage shall be fabricated and rigidly held in such a manner that the reinforcement will remain in proper position during the casting of the pipe. The minimum distance between the reinforcing steel and the surface of the pipe shall be $\frac{3}{4}$ in.

Sec. 3.6—Concrete for Pipe

3.6.1. *General.* The concrete may be placed by the centrifugal method, by the vertically cast method or by other approved methods.

3.6.2. *Proportioning.* The proportions of cement, fine aggregate, coarse aggregate and water used in concrete shall be subject to the approval of the engineer. The proportions shall be determined and controlled as the work proceeds, to obtain homogeneous, dense, workable, durable concrete of specified strength in the wall of the pipe and a minimum of defects in the surfaces of the pipe. The proportions shall be those which will give the best overall results with the particular materials and method of placing used for the work. A minimum of 7.0 bags of ce-

ment shall be used for each cubic yard of concrete. The water-cement ratio shall be such as to assure that the concrete will meet the strength requirements.

3.6.3. *Measurement of materials.* A barrel of cement shall be considered as 4 cu.ft. or 376 lb., and a bag of cement shall be considered as 1 cu.ft. or 94 lb. Cement in standard sacks need not be weighed, but bulk cement shall be weighed. Water for mixing shall be measured by volume or by weight. Concrete aggregates for each batch shall be measured separately by weighing. The proportions of aggregates shall be computed on the saturated and surface-dry basis and the water-cement ratio shall be exclusive of water within the aggregates and absorbed by them. The equivalent unit weights for both fine and coarse aggregates shall be determined in accordance with the "Standard Method of Test for Unit Weight of Aggregate" (A.S.T.M. C29), using a 1-cu.ft. cylindrical container. The equipment and devices for weighing and measuring shall at all times be accurate within 1 per cent.

3.6.4. *Mixing.* The mixing shall be thoroughly done by a mixer of approved type. Mixing time shall be at least three minutes. Transit mixing shall not be used except by written authorization and under specific requirements of the engineer.

3.6.5. *Standard test cylinders.* A set of at least four standard test cylinders shall be taken from each day's pour of the mixed concrete for pipe made by the centrifugal method, the vertically cast method or by other approved methods. Standard test cylinders shall be made and stored in conformance with the "Standard Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Field" (A.S.T.M. Designation C31). The curing of the test cylinders shall be in conformity with the curing of the pipe.

3.6.6. *Centrifugal test cylinders.* If the centrifugal method is used for making pipe, additional sets of four test cylinders of approved size and type shall be made by the centrifugal process at the beginning of the work and at intervals during the manufacture of the pipe. The number shall not exceed one set for each 400 lengths of pipe. Centrifugal cylinders shall be made by attaching to the spinning mold a test cylinder mold and placing the concrete within it by spinning at the same speed and for the same interval employed in the manufacture of the pipe. The concrete shall be spun in the centrifugal test molds in approximately 2-in. layers. The test cylinders shall be tested at the expense of the purchaser in an approved testing laboratory at 7, 14 and 28 days to establish and check ratios of strength of the two types of cylinders. Upon determination of this ratio, the strength of the concrete pipe shall be determined by application of the ratio of strengths obtained for the two types of test cylinders.

3.6.7. *Testing cylinders.* All test cylinders shall be tested by an approved testing laboratory at the expense of the purchaser, unless the manufacturer has approved testing facilities at the site of the work. In such event, tests may be made by the manufacturer in the presence of the engineer, or, if permitted by the engineer, certified test reports may be submitted by the manufacturer.

3.6.8. *Forms.* The forms shall be of steel made with butt joints throughout and with the interior surface smooth and true. All forms shall be sufficiently tight to prevent leakage of mortar; and they shall be stiff enough and so braced as to withstand, without deformation,

all operations incident to the pouring or spinning and setting of the concrete.

The forms shall be so constructed that the inner form (where pipe is vertically cast), outer forms, joint rings or end rings for forming the pipe joint and reinforçement shall be held in circular and concentric positions throughout the placing of the concrete; and so designed that the pipe can be stripped from the forms rapidly and without damage to the pipe surfaces. Forms shall be cleaned and oiled before each period of use.

3.6.9. *Strength of concrete.* Standard concrete cylinders shall attain a compressive strength of not less than 2,600 psi. in 7 days and 4,500 psi. in 28 days. Centrifugal test cylinders shall attain a compressive strength of not less than 3,500 psi. in 7 days and 6,000 psi. in 28 days. Pipe made from concrete which does not meet the strength tests will be subject to rejection.

3.6.10. *Placing concrete by centrifugal method.* The molds for forming the pipe shall be placed horizontally in a spinning machine. The method of placing concrete in the mold and the speed of rotation during placing shall be such as to prevent separation of concrete materials and the displacement of the steel reinforcement from its proper position and further, shall insure that the concrete will be evenly distributed and well compacted at the specified thickness throughout the length of the pipe. After the concrete has been deposited, the rotation shall be continued at a speed and for a length of time sufficient to provide the specified strength and sufficient compaction and bond to permit removal from the spinning machine without injury to the pipe. Excess water and laitance shall be removed from the interior surface of the pipe in an approved manner so that the surface shall be solid, straight and true. If necessary to provide a smooth surface, the interior shall be honed.

3.6.11. *Placing concrete by vertically cast method.* The transporting and placing of concrete shall be carried out by approved methods which will prevent the separation of concrete materials and the displacement of the steel from its proper position in the forms and the distortion of the forms. Approved methods of vibrating or rodding shall be used to compact the concrete in the forms to secure satisfactory surfaces of the pipe. The tops of the pipes shall be kept covered until the forms are removed. Forms shall not be removed until the concrete has set sufficiently to avoid spalling or damage to the pipe during the process of form removal.

3.6.12. *Other methods of placing the concrete.* If the contractor proposes to employ a method other than the centrifugal or vertically cast methods for placing the concrete within the mold, he shall submit for approval with his bid complete details of the method and equipment he proposes to use.

Sec. 3.7—Curing of Pipe

3.7.1. *General.* The pipe shall be cured by steam or by water unless otherwise specifically permitted. Steam shall be used for curing unless the temperature in the curing chamber is continuously above 50°F. Adequate space and facilities shall be provided for proper curing.

3.7.2. *Steam curing.* After the pipe has been cast, it shall be placed under cover for steam curing and when the concrete has hardened sufficiently, the pipe shall be kept in contact with moist steam at a temperature of at least 110°F. and not more than 150°F. for a period of at least 36 hours. Curing

by steam shall be continuous except during the period necessary to remove the forms or supporting rings. The forms shall not be removed until at least 6 hours after the beginning of curing. Water curing for at least 6 days, as specified below, may be used after forms are removed in lieu of steam curing.

3.7.3. *Water curing.* The pipe shall be kept moist by water spraying for a period of at least 36 hours. Following this minimum period, they may be "tipped" from their bases and removed to the storage yard where they shall be kept continuously moist by intermittent spraying for a period of at least 6 days.

Sec. 3.8—Testing of Pipe

3.8.1. *General.* Internal pressure and/or external loading tests of pipe at the manufacturer's yard will not be required unless they are specifically ordered by the purchaser, and such tests shall be at the purchaser's expense. The number of tests, type of tests and specific conditions of acceptance or rejection shall be as specified by the purchaser. Following are suggested procedures for hydrostatic pressure tests and crushing strength tests on fully cured and surface dry pipes:

3.8.2. *Hydrostatic pressure tests.* Hydrostatic pressure tests on pipe and joints may be made together by attaching two pipes together or a pipe and a standard joint section, or the tests may be made separately. The test section shall have suitable steel bulkheads attached to the ends and shall be filled with water and permitted to stand under a pressure of 10 psi. for a 2-hour period. The pressure shall be gradually increased until it reaches 120 per cent of the pressure for which the pipe is designed. It should be kept under the test pressure for at least 20 minutes and no cracks or measurable leakage should develop during the test period. Damp spots or water drops developing on the surface of the pipe should not be considered as leakage and cause for rejection. The joint should show no leakage at the test pressure.

3.8.3. *Bearing or crushing strength test.* This test should be in accordance with the 3-edge bearing test as described in A.S.T.M. Designation C76 for "Reinforced Concrete Culvert Pipe." Unless specifically required by the purchaser, the test should be limited to the loading required to produce the first 0.01-in. crack 1 ft. long, as described in that specification. The test should include the bell and spigot ends of the pipe and the loading block and bottom bearing strips should be shaped properly over the ends and provided with bearing caps of cement mortar. To avoid the necessity of applying loads in excess of the capacity of the loading machine, large pipe should be cut and tested in sections. The purchaser shall stipulate conditions as to loading and acceptance in accordance with external load for which the pipe is designed.

3.8.4. *Field testing.* Field tests on completed portions of the pipe line are not covered by these specifications for the manufacture of the pipe but should be included in specifications for pipe laying.

Section 4—Specials and Fittings

Sec. 3-4.1—General

The manufacturer shall furnish all fittings and special pieces required for closures, curves, bends, branches, manholes, air valves, blowoffs and connections to main-line valves and other pipes

shown on the contract drawings or ordered by the purchaser. Specials shall conform to the details furnished by the purchaser or—if required—to the details furnished by the manufacturer and approved by the purchaser. Either of two types shall be used:

Type A—specials of cut and welded steel-sheet cylinder of approved thickness, concrete or mortar lining and reinforced concrete or mortar exterior covering;

Type B—specials of cut and welded steel plate of approved thickness, with mortar coating on the interior and exterior.

Sec. 4.2—Specials (Type A)

The steel sheet shall be cut, shaped and welded to form the properly shaped bend, tee, reducer or other special. The welds shall be inspected, and the completed cylinder shall be tested for tightness by an approved method, if specifically required by the purchaser. A cage or cages of steel reinforcement with approved cross-sectional areas shall be formed around the cylinder and openings. Longitudinal reinforcement sufficient for the additional stresses in the pipe walls shall be provided. The interior and exterior concrete or mortar shall be placed in an approved manner.

Sec. 4.3—Specials (Type B)

4.3.1. The steel plate for the fabricated steel plate specials shall be cut, shaped and welded so that the finished special shall have the required shape and interior dimensions. The deflection angle between adjacent courses of a bend shall be not greater than 22½ deg. Adjacent courses shall be joined by butt welding. The minimum length of the courses shall be one-half the diameter of the pipe. The welds shall be inspected and the completed cylinder shall be tested for tightness by an approved method, if specifically required by the purchaser.

4.3.2. Wire-mesh reinforcing shall be applied to the interior and exterior surfaces of the fabricated special. It shall be 2 × 4 in. No. 13 gage welded wire fabric, held ⅜ in. from the surfaces of the steel plate. The members on the 2-in. spacing shall extend circumferentially around the special with ends overlapped 4 in. and tied together. Longitudinal splices shall be staggered.

4.3.3. The steel plate specials shall be lined and coated with mortar deposited on the surfaces by an approved method. The thickness of the mortar shall be such that the minimum cover of steel reinforcing shall be ¾ in. The mortar shall contain not less than 1 part cement to 4 parts sand, of a grading approved for the method of application used, and shall develop a 28-day compressive strength of not less than 3,500 psi.

Sec. 4.4—Curing Mortar Coatings on Specials

The mortar-coated specials shall be cured either by water spraying, by steam, or by curing compounds, as specified under Sec. 3.7 herein.

Sec. 4.5—Curves, Bends and Closures

Horizontal and vertical long-radius curves shall be formed by straight pipe in which joints are beveled. The total angular deflection for beveled pipe shall not exceed 5 deg. at any joint. Slight deflections may be made with straight pipe, provided that the maximum joint opening caused by such deflections shall not exceed ¾ in. for 36 in. and smaller pipe and 1 in. for pipe larger than 36 in. Short-radius curves and

closures shall be formed by fabricated specials of either of the two types specified in Sec. 4.1.

Sec. 4.6—Openings and Connections

Manholes and flanged, spigot or bell connections for air valves, blowoffs or connections to other pipes shall be built into the walls of the concrete pipe at locations shown on the contract drawings or ordered by the purchaser. Wall openings shall be formed by welding fittings of cast steel or fabricated structural steel of approved design to a saddle plate or to the reinforcing cage of straight pipe. If required, the interior and exterior surfaces of structural steel connections shall be lined and coated with reinforced mortar as specified in Sec. 4.3.

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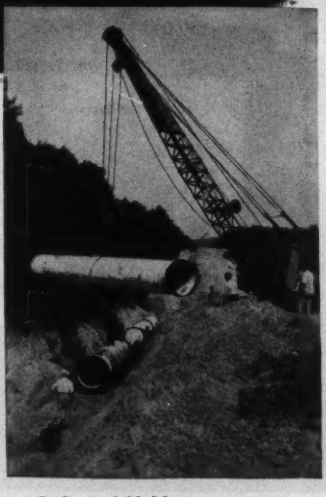

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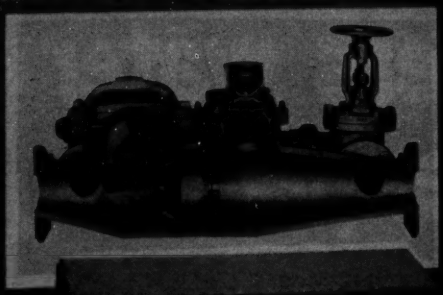

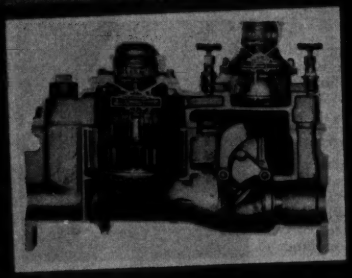

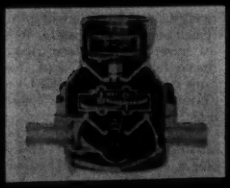

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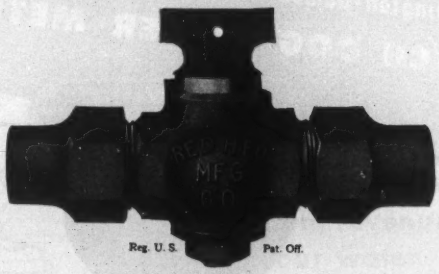
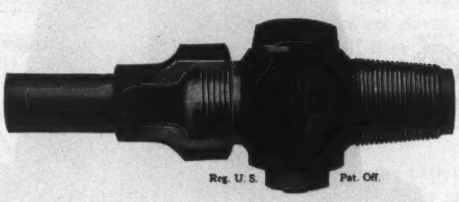


Fig. 415



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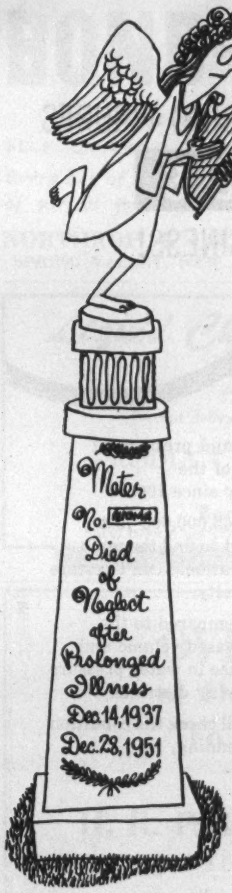

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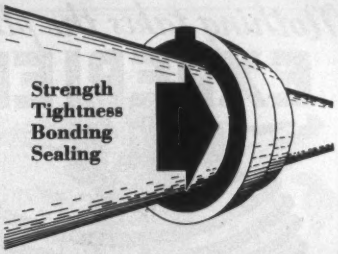

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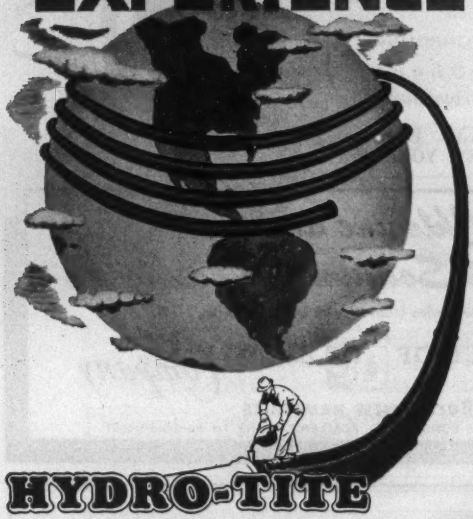

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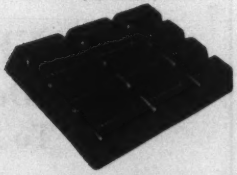

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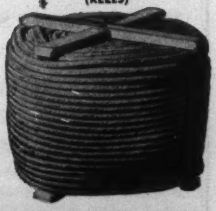

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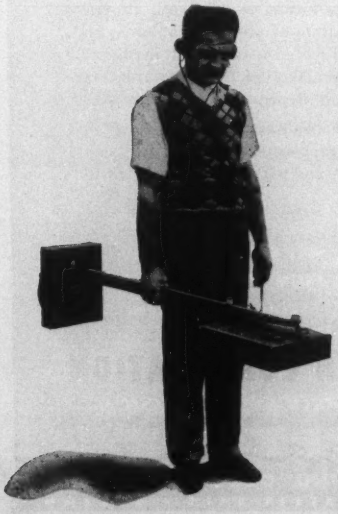

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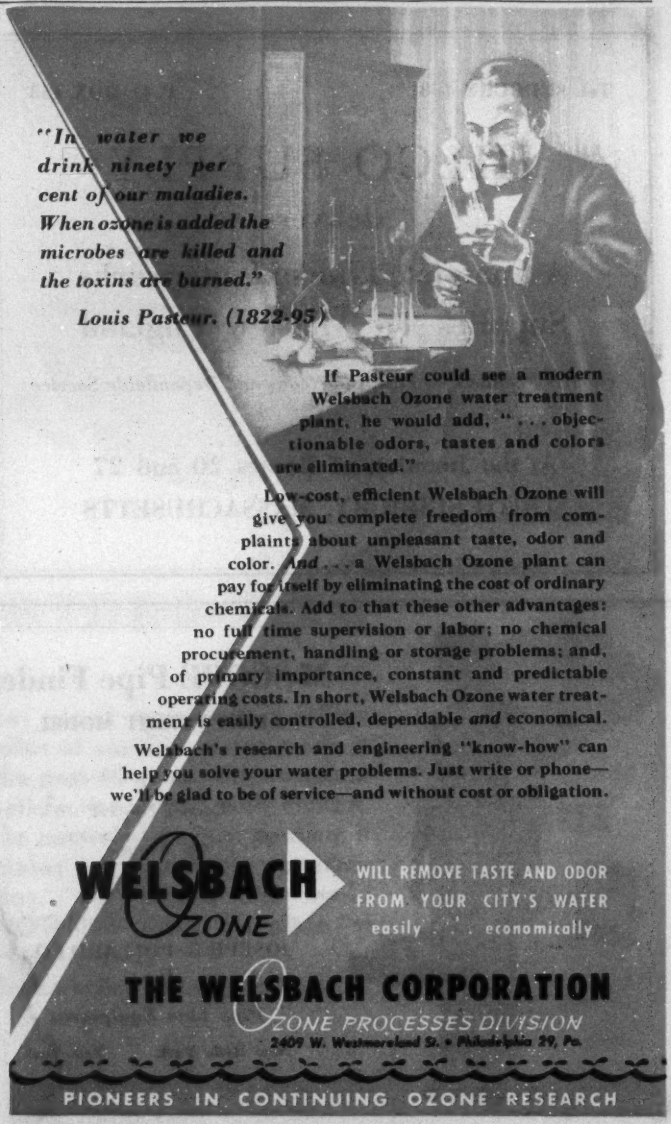

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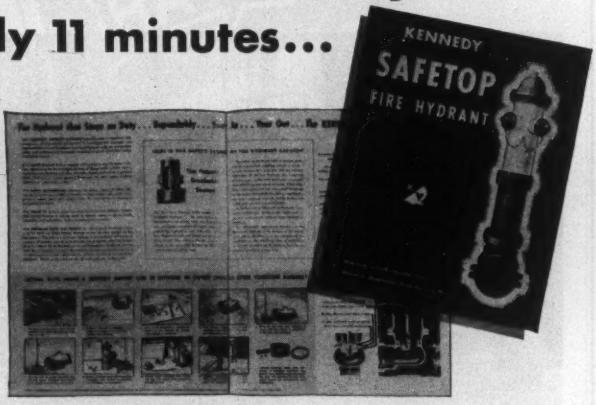

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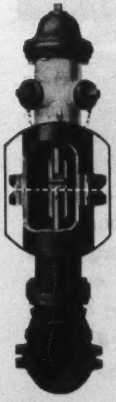

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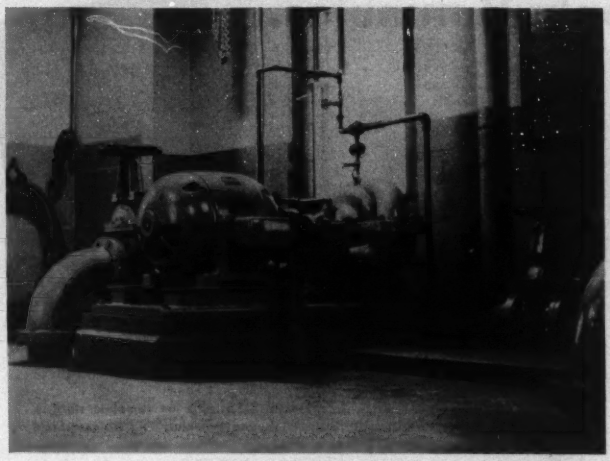

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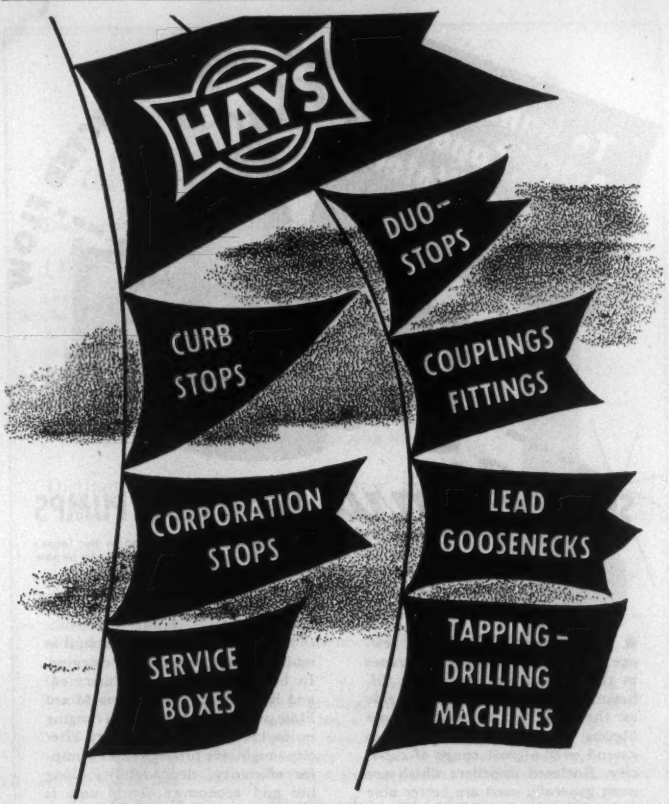

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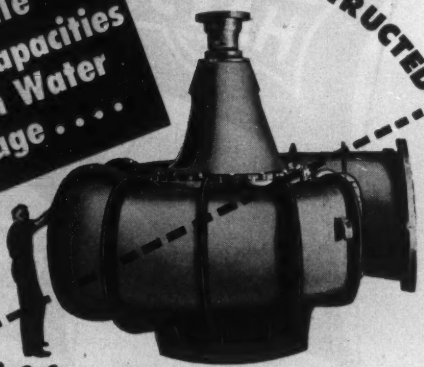
To handle LARGE Capacities of Storm Water or Sewage . . . .

With UNOBSTRUCTED FLOW



SPECIFY *Morris* MIXED FLOW PUMPS

The most practical type of pump, in the larger sizes, for abrasion resistance and ability to handle large stringy solids without clogging.

● In the Morris Mixed Flow sewage pump there are no guide vanes in the suction, nor stationary diffusion vanes on the upstream side of the impeller, to catch longer fibrous material. High efficiencies extend over a great range of capacity. Enclosed impellers which are most generally used are better able to withstand the abrasive action of grit and dirt. Initial capacity and efficiency are maintained over a longer period of time.

Special Feature...

Morris Mixed Flow Pumps have no internal bearings in contact with the sewage.

No other pump is so successful in maintaining freedom from clogging. In both vertical type (illustrated) and horizontal type, Morris Mixed Flow pumps have capacities ranging up to 150,000 G.P.M. In city after city, engineers prefer Morris pumps for efficiency, dependability, long life and economy. Every unit is backed by 84 years' experience in hydraulic engineering.

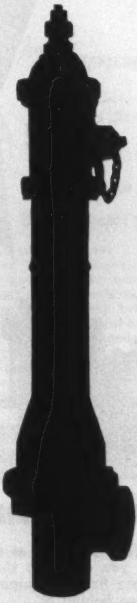
Write for your free copy of bulletin 178, describing Morris Mixed Flow Pumps

MORRIS MACHINE WORKS, Baldwinsville, N. Y.
STARKWEATHER ENGINEERING COMPANY
264 Walnut Street, Newtonville, Massachusetts

MORRIS CENTRIFUGAL PUMPS

EDDY

Valves and Hydrants

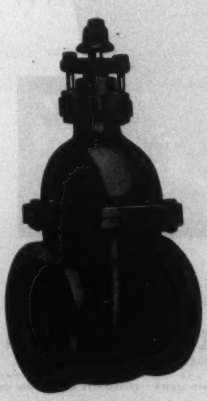


Distinctive Features of the EDDY Valves

ONLY three parts are moved by the Stem — the ball and the two gates. Each gate is hung from one of the trunnions on the ball. A convex surface at the base of each trunnion fits a concave surface on the back of the gate. This allows the gates to adjust themselves properly to their seats. . . . The gate, being free to revolve on the trunnions, do not always seat in the same position. Gates are center bearing and adjustable. They are forced to their seats with equal pressure at all points. There are two hooks on the ball on sizes 4-inch and larger, which loosely engage with the gates.

Distinctive Features of Our New Swivel Top Hydrants

THIS new hydrant has all the advantages of the popular EDDY fire hydrant, plus several additional features. . . . Nozzles are in a short flanged section of the standpipe, which may be unbolted and turned to different positions. . . . Should the standpipe be broken, only the casting below the swivel head need be replaced.



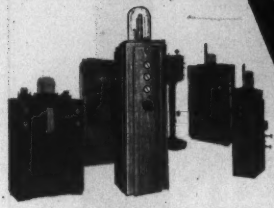
. . . To raise the hydrant to conform to a new grading, simply insert a flanged extension piece below the swivelhead. No digging. To add a steamer nozzle at any time, it is only necessary to replace the swivel head with one having a steamer nozzle.

Besides valves and hydrants to meet the most exacting demands of waterworks service, the complete EDDY Line includes: valves for sewage disposal works; valves for steam, gas and oil; check valves, foot valves, plug valves, shear gates, indicator posts, etc. EDDY valves are made in three classes: Iron Body Bronze Mounted, All Bronze, and All Iron Valves.

Eddy Valve Co.

WATERFORD NEW YORK

the part you don't see is important...



IN W&T CHLORINATORS, TOO!

When you look at a single W&T Chlorinator you can't see the basic research, the complete line of equipment, and the service that are behind it.

For instance, the engineer, the plant operator and the taxpayer all benefit from W&T's complete line of equipment. In the selection of equipment for a water supply — large or small — the engineer can always find a W&T Chlorinator to fit all requirements. The plant operator knows that this complete line can provide a W&T Chlorinator designed to help him provide safe water with his particular plant layout. The taxpayer is assured that money spent for W&T Equipment fitted to the present as well as the future needs of his community will provide long range economy.

These advantages of W&T's wide selection of equipment are probably one reason so many people use W&T Chlorinators.

WALLACE & TIERNAN COMPANY, INC.

CHLORINE AND CHEMICAL CONTROL EQUIPMENT

NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES

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BUILDERS

BUILDERS-PROVIDENCE

WATER and SEWAGE WORKS EQUIPMENT . . .

— for metering and controlling flow of liquids, air, dry materials. For Bulletins and complete information, address Builders-Providence, Inc. (Division of Builders Iron Foundry), Providence 1, Rhode Island.

BUILDERS-PROVIDENCE

Tegul-Mineralead*

AND

HYDE-RO RINGS

the best way to join bell and spigot pipe

Tegul-Mineralead, the original plasticized sulfur compound joint, is easy and clean to work with, economical, too — needs no skilled labor, caulking or deep bell holes. HYDE-RO RINGS, rubber ring packing, are recommended for use with Tegul-Mineralead. Please write us at 17 Walnut Street, Mertztown, Penna., and request Bulletin No. M10-1 and M10-5.

THE ATLAS MINERAL PRODUCTS COMPANY

MERTZTOWN, PENNA. HOUSTON, TEXAS

*Trade Mark Registered

Warren Foundry & Pipe Corp.

ALSO

Warren Pipe Co. of Mass., Inc.

SALES OFFICES

55 LIBERTY STREET, NEW YORK

75 FEDERAL STREET, BOSTON, MASS.

Manufacturers of

CAST IRON PIPE

Flanged Pipe *Flexible Joint Pipe*

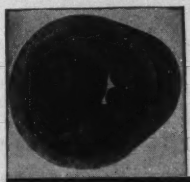
Bell and Spigot Pipe

Special Castings *Short Body B. & S. Specials*

Warren (WF) Spun Centrifugally Cast Iron Pipe

WORKS: PHILLIPSBURG, N. J. and EVERETT, MASS.

Large Stock Enables Us to Make Prompt Shipments



Get Full Service From Old Mains

The most practical way to meet today's overload demand is to clean clogged water mains. FLEXIBLE Underground Pipe Cleaning Co., specializes in such jobs— any size—2" to 72".

RAY BAHR

41 GREENWAY, HAMDEN, CONNECTICUT

New England Representative

Pipe Founders Sales Corporation

CAST IRON PIPE AND FITTINGS

FOR

Water, Steam, Gas and Culverts

Special Flanged and Bell and Spigot Castings

Lyncast Iron Chemical Castings

Office: 131 State Street, Boston 9 **Warehouse and Yard: East Cambridge, Mass.**

UTILITIES SUPPLY CORPORATION

Distributors of Water Works Supplies and Materials for Mains and Services

- Revere Copper Tubing, Type K
- Hays Brass Goods and Erie Service Boxes
- Buffalo Gate and Service Boxes
- Cast Iron Fittings—AWWA or Short Pattern
- Mineralead Jointing Compounds
- Construction Tools: Shovels, Cold Cutters, Lanterns, Picks, Sledges.
- Jointing Materials: Twisted or Braided Jute, Runners, Pots, Ladles, Hydro Rings, Pig Lead and Lead Wool.
- Furnaces: Complete Hauck Line.

Office and Warehouse

425 Riverside Avenue

MEDFORD, MASSACHUSETTS

My 8-9023

My 8-9024

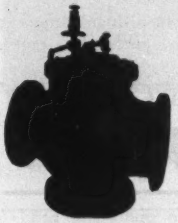
1879—ROSS— 1879

AUTOMATIC VALVES

Controls elevation of water in tanks, basins and reservoirs

ALTITUDE VALVE

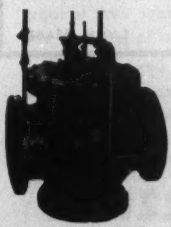
1. Single Acting
2. Double Acting



Maintains desired discharge pressure regardless of change in rate of flow

REDUCING VALVE

Regulates pressures in gravity and pump systems; between reservoirs and zones of different pressures, etc.



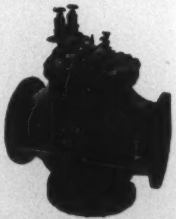
Maintains levels in tank, reservoir or basin

1. As direct acting

2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

FLOAT VALVE

A self contained unit, with controls three or more automatic



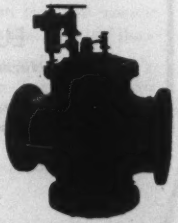
COMBINATION VALVE

Combination automatic control both directions through the valve.

Maintains safe operating pressures for conduits, distribution and pump discharge

SURGE-RELIEF VALVE

Electric remote control—solenoid or motor can be furnished



REMOTE CONTROL VALVE

Adapted for use as primary or secondary control on any of the hydraulically controlled or operated valves.

ROSS VALVE MFG. CO., INC. Box 592 TROY, N. Y.

Horton Steel Tanks

For Municipal Service

The Horton ellipsoidal-bottom elevated steel tank shown at the left provides water pressure in the distribution system at Windham Center, Me. It has a capacity of 200,000-gals. and is 79 ft. to the bottom.

In addition to ellipsoidal-bottom elevated tanks, we build radial-cone bottom tanks in sizes from 500,000 to 3,000,000-gals., reservoirs, standpipes and steel plate work of all kinds.

We shall be glad to furnish quotations or additional information on Horton tanks.

CHICAGO BRIDGE & IRON COMPANY

201 Devonshire Street, Boston, Massachusetts

Eastern Plant — Greenville, Pa.

Attention Mr. Water Works Superintendent ! !

CEMENT LINED SERVICE PIPE:—

Resists Corrosion

Has proven practical for nearly three-quarters of a century

Immediate delivery can be made to waterworks on both wrought iron and steel, black or galvanized.

"SPECIFY EUREKA PIPE"

EUREKA PIPE COMPANY, Inc.

Manufacturers of CENTRIFUGAL CEMENT LINED PIPE and LEAD AND TIN LINED FITTINGS

591-593 WASHINGTON ST. TEL. 3-9550 LYNN, MASS.

Cutting Valve Costs for a lifetime

This interesting assembly consists of a 20 inch Rensselaer valve with reducing and increasing sections for installation in a 30 inch pipe line. The integral type gear case is designed for the working pressure of the valve and is packed with oil for lifetime service.

There is no need for a concrete vault for valves equipped with integral type gear cases. Just install valve boxes, shovel back the dirt and forget it, for this is the Rensselaer double disc valve with the well known wedge action. On closing, when the gates reach a position opposite their seats, the powerful wedging action presses them squarely and firmly against their seats. It is impossible to damage the stem threads or throw the stem out of alignment, and the gates open and close easily.

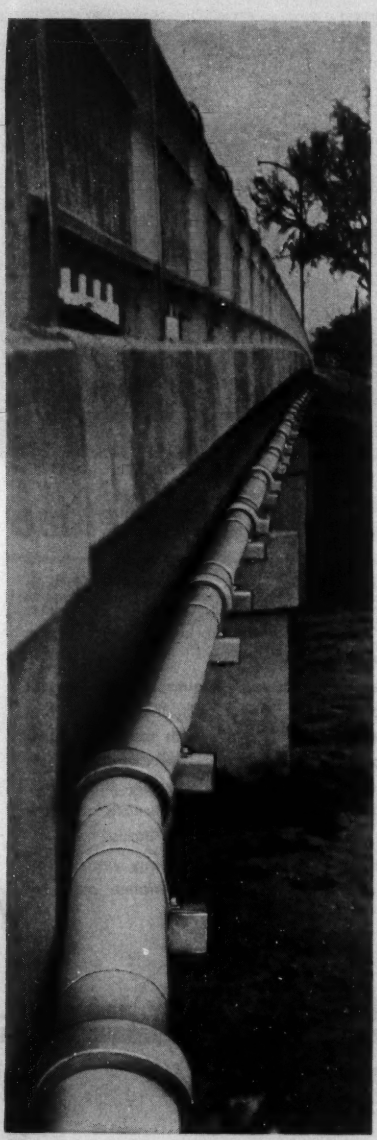
The valve you buy today should serve faithfully for many years. Why not provide maximum insurance against future maintenance costs by putting in Rensselaer valves in the first place?

Rensselaer VALVE COMPANY, TROY, N. Y.

A DIVISION OF NEPTUNE METER COMPANY

Sales representatives in principal cities

102



Run of "Century" Asbestos-Cement Pressure Pipe supported on bridge. Note that "Century" Pipe needs no protective painting; external corrosion factors can't affect it.

where permanence counts . . .

"Century"® asbestos-cement pressure pipe!

Strong . . . durable . . . a water main that will successfully resist exposure to the elements without need of protective treatment—that's "Century" Pipe!

Consider the strength factors that this run of "Century" Pipe has in common with the supporting bridge:

"Century" Pipe is made of practically indestructible materials—Portland cement, reinforced with strong, tough asbestos fibers.

Like the bridge, "Century" Pipe has been built with an extra margin of safety to make certain it is *stronger than it will ever need to be.*

And, like the bridge, "Century" Pipe can "take" traffic vibration. The "Century" Simplex Couplings actually cushion both ends of each pipe section in rubber—which helps to absorb the shocks and vibrations of passing traffic.

When, in addition to the strength of "Century" Pipe, you consider the other long life factors—resistance to corrosion, tuberculation, and electrolysis; and the economy—the fact that it can be laid quickly with a minimum of special skills; you'll quickly see why *before you buy or specify any pipe for water mains, it will pay you to investigate "Century" Asbestos-Cement Pressure Pipe.*

WRITE FOR FREE BOOKLET, "Mains Without Maintenance." Contains valuable reference material, specifications, and data for anyone interested in pipe for water mains. FREE—write for it.

Nature made Asbestos . . . Keasbey & Mattison has made it serve mankind since 1873

K&M best in asbestos®

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WROUGHT IRON PIPE. (See Pipe, Wrought Iron and Steel.)

to aid peak defense production

Collect and Sell your Iron and Steel Scrap

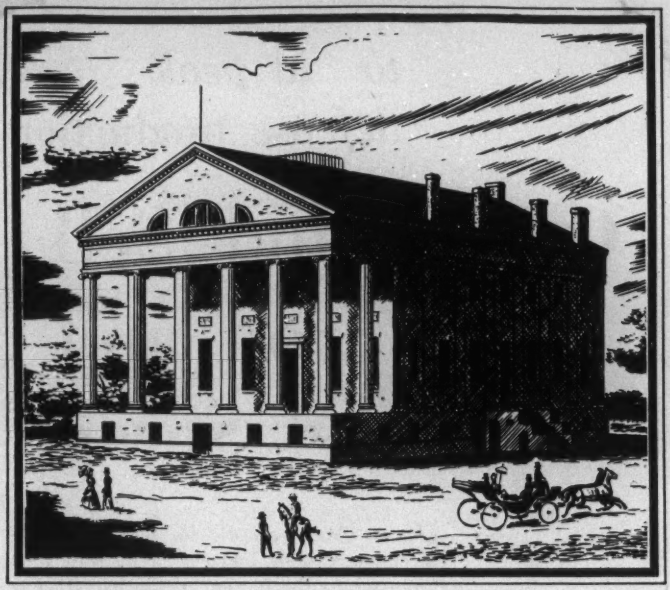
Mr. Q-Check says *dig* for scrap metal — *search* every nook and corner of your pipe yard—*scrape* the bottom of the barrel! For iron and steel scrap is critically needed to aid peak defense production in steel mills and iron foundries.

The average pipe yard has some or all of the following sources of scrap metal, according to whether pipe is used for water, gas, sewerage or industrial service:

Obsolete fittings; cut pipe (short pieces of distribution or service pipe); damaged hydrants, valve boxes, manhole covers, etc. It all adds up to a vital contribution to defense production.

Collect your scrap now. Phone your nearest scrap dealer. He wants what you have *but quick*, and pays good cash prices.

CAST IRON PIPE RESEARCH ASSOCIATION . . . CHICAGO



Richmond's State Capitol, completed in 1792, as it looked 100 years ago

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